

Establishing appropriate Socio-Cultural and Environmental design strategies for Residential Buildings in Baghdad: Learning from the vernacular

By

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A thesis submitted in partial fulfilment of the requirements for the degree of Doctor of Philosophy

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Abstract

The issue of energy conservation and rationalisation of consumption is one of the most important issues in the modern era, particularly in the building sector, with the residential sector consuming about 48% of the total national energy usage, where most of it is consumed in the operations of supplying the building with cooling and ventilation in the summers and heating during the winters. In search of future sustainability, it can be seen that Baghdad city's housing is of two types: authentic architecture that embodies vernacular passive design strategies and contemporary design reflecting global sensibilities. However, it can be argued that neither of these housing typologies provide residents with both adequate comfort levels and efficient energy usage. This study aims to recognize and assess the cultural and environmental relevance of vernacular and contemporary housing in Baghdad, Iraq in order to establish a set of appropriate design approaches to inform future housing designs in Iraq, which can both enhance comfort levels while decreasing energy usage while remaining culturally responsive. In doing so, this study seeks to review previous literature to understand the current state of knowledge in this field of study and provide an academic basis for the identification of climatically appropriate passive design strategies. The study has included bioclimatic analysis using the psychrometric chart for Baghdad that analyses and identifies feasible passive strategies for application in Baghdadi climate. Most notably, however, this work aims to understand the public's (the market's) satisfaction with both contemporary and vernacular houses with regards to environmental and cultural performance. Further, experts' perceptions of the potential for inclusion of passive design strategies in future Baghdadi housing designs were also evaluated.

Findings from these four investigations: literature, bioclimatic analysis, public and professional perspectives were undertaken in the themes of the urban fabric, and architectural design factors and findings were subsequently synthesised to inform decisions on those passive design strategies most appropriate for adoption in future designs for new housing in Baghdad. These future design strategies will require a combination of contemporary technology with passive design fundamentals in order to provide better and naturally welcoming housing solutions that can satisfy both functional expectations and social needs.

Dedicated to

my mother and father

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Chapter 1

Introduction

Chapter 1

1.1 Background: The Contribution of Vernacular Techniques to Low-energy Design

This research is inspired by the conviction that new housing design is needed in the future in Baghdad, Iraq, in which contemporary design is combined with the traditional vernacular for great value.

Vernacular architecture involves the interaction between environmental factors (location, topography, and climate) and cultural values (religion, tradition, and background). It reflects people's views of the environment as a living entity. Due to the lack of technology in the past, passive heating and cooling strategies were used. These were based on available resources and a variety of criteria such as orientation, form and local materials. Vernacular architecture represents a view that emerges at different levels in both urban planning and architectural design, and is shaped by the beliefs and actions of occupants who have committed to a way of life with social ideals (Coch, 1998; Engin et al., 2007; Fathy, 1986). Communities have learned from experience that their welfare is fundamentally dependent on maintaining harmony with the surrounding environment (Fathy, 1986) and that knowledge derived from vernacular architecture can provide the basis for the development of low-energy design (Singh, Mahapatra, and Atreya, 2011). There have been a series of studies from different countries and climatic zones aimed at proving scientifically that the features of vernacular architecture are relevant and feasible today. For example, those of Shanthi Priya et al. (2012), Singh, Mahapatra, and Atreya (2011), Zhai and Previtali (2010), Singh et al. (2010), Engin et al. (2007), Martin (2004), and Kimura (1994), who discuss the advantages and effectiveness of the use of vernacular techniques for improving energy efficiency.

The profession of architecture has dramatically changed in the last two decades. The energy prices have risen immensely and hostilities, as well as energy blackouts along with climate change, have laid burdens on the global population. Hence, the condition of the environment has brought a large impact on the design of buildings (Smailes and Hugo, 2003). Architects and designers have realized that criteria for good designs do not only include constructing buildings with all the comfortable amenities. The main goal is to design buildings in which the design considers the environment as well as natural factors (Smailes and Hugo, 2003).

Most contemporary buildings across the world do not respond to the environment. Usually, 69.9% of contemporary domestics in Iraq are air-conditioned and make use of concrete and glass (Atif, 2018). However, it is argued here that architects must design houses with consideration for the environment as well as energy consumption (Bell, 2008). Presently, the design for sustainable construction is a big challenge that is faced by most architects. Many architects worldwide have adopted new procedures, methods, and use of innovative technology for developing designs for sustainable buildings from the late half of the 1980s (Bell, 2008). However, in many developing countries, including Iraq, it seems that a somewhat conscious attitude is missing.

The three main dimensions in the fundamentals of sustainable development are shown below in Table 1.1 (Edgar and Lahham, 2008).

Table 1.1: *The three main dimensions in the fundamentals of sustainable development*

Dimension	Description
Economic	Human as well as natural resources should be fully utilized to enhance society.
Social	The relation between nature and humans.
Environmental and the preservation of resources	Ecological, biological as well as physical systems along with their advancement and reproduction.

Source: *Researcher according to Edgar and Lahham (2008)*

The main feature of a sustainable building is not only to provide a comfortable lifestyle for users but also to consider the resulting effects on the environment. As Edgar (2007) indicates, the fundamentals of sustainable development are focused on building techniques, materials used, water systems, indoor air quality, daylight strategy as well as energy efficiency. These fundamentals are categorized through two themes: passive and active design, as shown in Table 1.2 (Abdelsalam and Rihan, 2013).

Table 1.2: *Passive and active design*

Theme	Features
Active design	Reflect the dependence on grey water systems, waste recycling, micro power generation, wind turbines and photovoltaic systems (Figures 1.1 & 1.2).
Passive design	Reflect the dependence on passive thermal performances (mashrabiya or shanashel, double thick walls along with vaults and domes) and on compact layout for reducing heat gains and losses, and passive ventilation (courtyard and wind catcher).

Source: Researcher according to Abdelsalam and Rihan (2013)

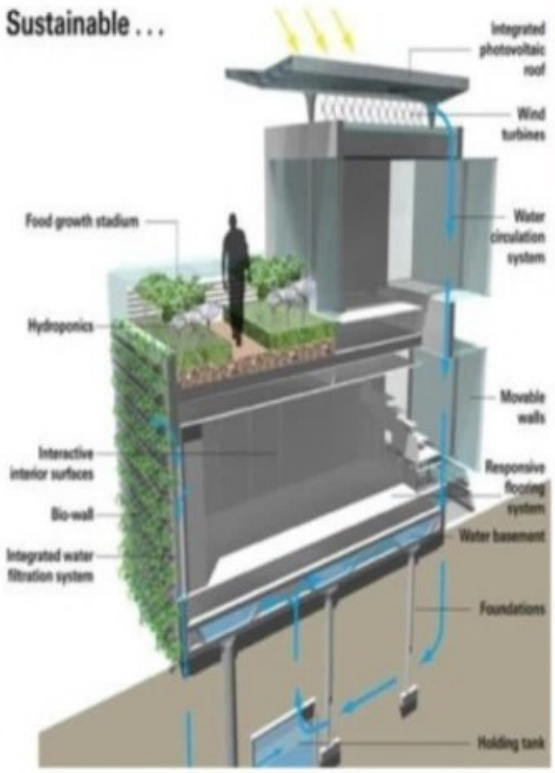


Figure 1.1: *Elements of the modern technology trend in a residential building*

Source: Owen (2010)



Figure 1.2: *Elements of modern technology trend in a single-family unit\ BedZED*

Source: Researcher(2019)

Early design stages offer the greatest opportunities to influence the environmental performance of buildings at low costs and rates (UNEP 2011; WBCSD, 2009). In architectural designs, form is an important input and is related to the space and the activities performed in this space (Bacon, 1974) because it refers to the contact point

formed between space and mass. In an architectural space, factors which have an impact include colour, shading, lighting, materials, textures, as well as architecture forms. It is worth mentioning that the designer's skills in terms of making use of these elements, indoors as well as in spaces around buildings, is reflected by the overall quality of the architecture (Bacon, 1974). The importance of form for sustainable design is explained by Behling's diagram reproduced below (Figure 1.3).

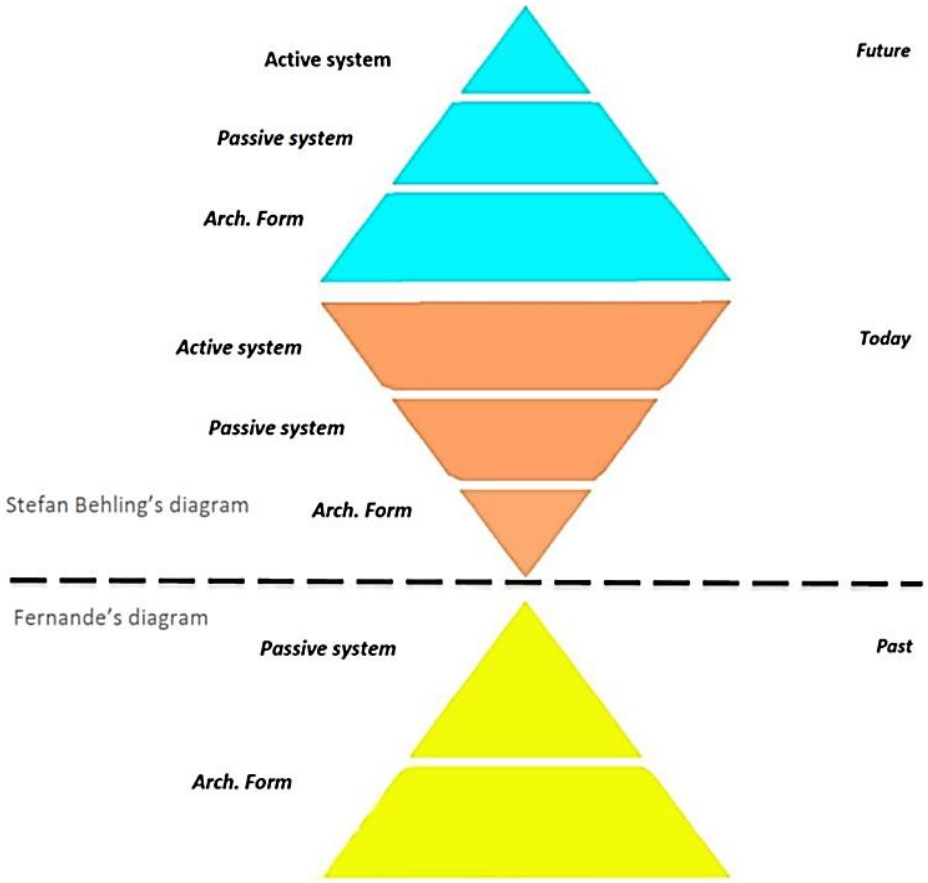


Figure 1.3: *Behling's diagram (present and future triangles) (Abalos, 2009)*

This diagram, in Fig. 1.3, clearly shows that for future designs it is important to consider passive systems as well as architectonic forms for reducing reliance on active systems. It seems valid to add a new triangle which represents the past. The two elements included are passive systems and architectonic forms (Abalos, 2009). For future planning the

historic triangle is extremely important and relevant. This is because it can assist with comprehension of the two steps which can mark the initial stage in adapting and enhancing the approaches utilized in certain vernacular designs. This will make them further adoptable for contemporary design procedures. Furthermore, adequately designed systems can lead to reduction in energy consumption due to reduction in the need for active systems.

Moreover, this idea was supported by a number of studies on vernacular buildings and their thermal performance. These studies showed that such buildings attained adequate thermal comfort levels through most of the year with just the use of passive approaches. Also, it was found that indoor temperatures remained almost constant in some cases (Cardinale, Rospi, and Stefanizzi, 2013; Priya et al., 2012; Singh, Mahapatra, and Atreya, 2010). Hence, such findings confirm the feasibility of using passive approaches in contemporary buildings (Molodin, 2016; Priya et al., 2012).

Therefore, a blend of traditional aspects with modernization must be pursued in the future definitions of architecture and design. A hybrid system must aim to include traditional design techniques and allow for the evaluation of functional concepts and new aesthetic features (Kimura, 1994; Abalos, 2009). It would be a mistake to ignore the technological potential, as well as knowledge, which exists today when aiming to achieve high-performance, sustainable buildings (Leatherbarrow and Wesley, 2009).

Passive design is a conventional concept and has been a key factor in building designs since building structures were first introduced by humans. The local climatic conditions were a major consideration for the survival of the structures and also for delivering internal environments that were more comfortable for the occupants. The regions that experience harshest climatic conditions, such as the Middle East with hot, dry areas and the American northeast with extremely cold winters, are classic examples. The passive design utilizes natural processes instead of active systems and reduces energy consumption. However, it is not possible to apply all the strategies mentioned here. The logical solution is to adopt the most appropriate strategies to efficiently decrease the environmental impact of the building. The efficient and intelligent implementation of a few passive designs can yield impressive results where the buildings show optimal performance.

1.2 Research Gap

A few attempts have been made to produce applicable studies on the vernacular and contemporary architecture in Iraq. These include the works of Fethi (1982), Warren (1984), Al-Azzawi (1984), Al-Douri (1984), Al-Kaissi (1984), Edward (2006) and Salman (2016). In fact, most of these studies targeted the vivid architectural histories, showing how this kind of architecture worked previously. As such, existing studies have mainly aimed to classify, list and describe the features and types of houses. Salman (2016) has given some attention to vernacular strategies in a modern-day context along with the investigation of the occupants' perspectives on both traditional and modern houses in Baghdad (Salman, 2016). Moreover, the way vernacular architecture works at present and can possibly operate in the upcoming years, along with its connection to thermal performance and energy use, is an ignored area. Examination of the literature indicates that most studies have remained at the level of explaining the problem and have failed to analyze the problem and examine it systematically. Moreover, most of these studies (Fethi, 1982; AlKaissi, 1984; Al-Douri, 1984; Al-Azzawi, 1984; Warren, 1984) are quite old. Hence, they may not be applicable considering the changes in the climate and in particular the social culture of the country (Iraq).

Neither the opportunities which traditional approaches could provide nor the complexities of their use in the architecture of today have been adequately investigated recently. Therefore, an understanding of the traditions of the local buildings is needed in order to be adapted into normal architecture and design (Al-Azzawi, 1984). Thus, there is a need for more analytical and practical studies that can explain the process by which vernacular architecture works at present and how it can operate for future constructions in terms of its thermal and energy performances. There is also a need for studies which can apply vernacular approaches to upcoming designs for the domestic sectors. These can then be tested for their particular energy requirements for delivering comfort and for evaluating their environmental performance (Salman, 2016). One such idea may be to carry out a focus group to obtain opinions on future designs based on vernacular strategies (Salman, 2016).

It can be seen that, to date, no work published has investigated the bioclimatic analysis, public and professional perspectives on these factors. This research intends to apply a

combination of bioclimatic analysis and analysis of questionnaires with mainly quantitative responses and qualitative interview responses. The data will be subsequently synthesized to inform decisions on those passive design strategies most appropriate for adoption in future designs for new housing in Baghdad. It is expected that this novel research will be able to address the modern-day challenges in terms of the construction of sustainable environments by forming an awareness of the relevancy of vernacular aspects.

1.3 Research Aim, Hypothesis, and Objectives

The central theme of the current study is to recognize and assess the cultural and environmental relevance of vernacular and contemporary housing in Baghdad, Iraq. The study aims to establish a set of appropriate design approaches to inform future housing design in Iraq, which can enhance comfort levels yet decrease energy usage along with cultural responsiveness. Therefore, this study will consider the advantages of passive designs and vernacular courtyard houses for future architectural buildings in terms of both the local environment and cultural responsiveness.

This overarching aim can also be termed as **a hypothesis –** as follows:

- Vernacular houses in Baghdad, Iraq, are more appropriate for the ambient environment than contemporary houses.
- It is possible to establish a set of socially and culturally appropriate design approaches to inform future housing design in Iraq, which can enhance comfort levels yet decrease energy usage through combining learning from vernacular design, bioclimatic design as well as consultation with householders (public) and built environment professionals.

To achieve the aim of this study and respond to the research challenges, a series of objectives have been developed to guide the study:

1. *Identify and analyse feasible passive strategies for application in Baghdadi climate;*
2. *Examine the levels of householders' (public) satisfaction with both, contemporary and vernacular houses with regards to their environmental (comfort and energy) and cultural performance;*

3. *Explore the perceptions of built environment professionals relating to design and construction of modern housing units and their incorporation of passive strategies in Baghdad;*
4. *Propose a framework for design strategies for new housing units in Baghdad, that appropriately combines contemporary technology with passive design fundamentals in order to provide comfortable and energy efficient housing solutions that are able to satisfy householder's functional expectations as well as social and cultural expectations and needs.*

Research Question

To achieve the aim of this study and respond to the research challenges, a series of research questions have been developed to guide the study, as shown in Table 1.3:

Table 1.3: *Traceability matrix of research objectives, research questions and chapter's addressed*

RO1	Identifying and analysing feasible passive strategies for application in Baghdadi climate.	**RQ1**	What passive design strategies are feasible for application in the Baghdadi climate?	**Ch. 4**
RO2	Examine the levels of householders' (public) satisfaction with both, contemporary and vernacular houses with regards to their environmental (comfort and energy) and cultural performance.	**RQ2**	To what extent are householders' (public) satisfied with contemporary and vernacular houses with regards to their environmental and socio-cultural performance?	**Ch. 5**
RO3	Explore the perceptions of built environment professionals relating to design and construction of modern housing units and their incorporation of passive strategies in Baghdad.	RQ3	What are built environment professionals' perceptions of feasibility and deliverability of the design and construction of modern housing units incorporating passive strategies in Baghdad?	**Ch. 6**
RO4	Propose a framework for design strategies for new housing units in Baghdad, that appropriately combines contemporary technology with passive design fundamentals in order to provide comfortable and energy efficient housing solutions that are able to satisfy householder's functional expectations as well as social and cultural expectations and needs.	**RQ4**	What should be included in a framework for design strategies for new energy efficient and socio-culturally appropriate housing units in Baghdad?	**Ch. 7**

Legend: RO = Research Objective; **RQ** = Research Question

1.4 Research Methods and Flow

The research is organised in four main stages: literature review, Bioclimatic analysis, Public survey, Expert Consultations, and Synthesis of findings from stages 1,2,3, and 4.

Table 1.4 shows the traceability matrix of research stages and chapters addressed

Table 1.4: *Traceability matrix of research stages and chapter addressed*

Research Stage	Chapter addressed
Stage 1 *Bioclimatic analysis*	***Chapter 4*** *Bioclimatic analysis using psychrometric chart for Baghdad*
Stage 2 *Public survey*	**Chapter 5 &** **Chapter 6** ***Engaging Stakeholder***
Stage 3 *Expert Consultations*	
Stage 4 *Synthesis of findings from stages 1,2,and 3*	**Chapter 7** *Discussion: Framework for Design Strategies for Future House in Baghdad*

Source: *Researcher*

Below are the important stages that make up the structure of the study to fulfil the objectives and aim of this study. This involves different theoretical and empirical investigations. The stages involved are:

1. ***Bioclimatic analysis using psychrometric chart for Baghdad:*** Identifying, analysing and implementing of climatic strategies which have an influence on reducing the consumption of energy along with taking into consideration the plausible solutions for construction attained at active and passive levels. This will be addressed in chapter four;
2. **Public perception survey*:*** Satisfaction with both contemporary and vernacular houses with regards to environmental and cultural performance. This will be addressed in chapter five;
3. **Expert perception Survey*:*** Exploring the perceptions of built environment professionals relating to design and construction of modern housing units incorporating passive strategies in Baghdad, for example academic, government and private sector. This will be addressed in chapter six.

To achieve ***Stage 4,*** a synthesis of findings from public survey, expert survey and Bioclimatic analysis using psychrometric chart for Baghdad along with conclusions drawn from the relevant literature findings to inform design strategies for new residential units in Baghdad needed for incorporating various modern technologies using passive design procedures to provide an enhanced, and naturally appealing housing possibilities and solutions that will fulfill social and functional demands. This will be addressed in chapter seven.

1.5 Contribution to Knowledge

The following points summarise the contribution to knowledge sought from this research:

1. A comprehensive literature review outlining the thermal comfort and energy efficiency challenge faced by dwellings in Baghdad, in the context of current standards and regulations. This includes a historical look at dwellings which focuses on vernacular designs used in Baghdad. For some aspects, there was a lack of peer-reviewed literature specific to Baghdad, in such cases, relevant literature relating to comparable climates was considered.
2. A bioclimatic analysis of building design relevant to the Baghdadi climate. The results indicate that the most efficient passive strategies for the whole year for Baghdad are the solar shading of windows, natural ventilation, direct evaporative cooling, and heating along with added humidification if required. All these strategies can be incorporated within a building to achieve as many hours as possible of comfort, energy saving, and enhanced low energy use in the climate of Baghdad. Many of the strategies favoured by bioclimatic building design could be found in Baghdadi vernacular dwellings but not in contemporary dwellings.
3. Examining the public's satisfaction with both contemporary and vernacular houses with regards to environmental and cultural performance. This information was used to inform decisions on which passive design strategies to implement in the design strategy for new housing in Baghdad.
4. Engaging with professionals and understanding their ideas on designs and construction in terms of passive designs of modern housing units in Baghdad, for example academic, government and private sector.

5. Propose a framework for design strategies for new housing units in Baghdad, as a case study, which required a combination of contemporary technology with passive design fundamentals to provide better and naturally welcoming housing solutions that can satisfy functional expectations as well as social needs. This research will develop a new approach to inform contemporary building design to assist developers, architects, contractors, academia, policymakers and the local authority of Baghdad with concepts that hence improve the construction of additional energy-saving and sustainable buildings in Iraq and can be useful for other areas in Iraq and other similar cultural and climatic regions, such as Kuwait, Syria, and some areas of Saudi Arabia.
6. The Ministry of Planning, Iraq (2019) declared that Iraq has the potential to achieve sustainable developments and energy-efficient design by 2030 (Ministry of Planning, 2019). Hence, this research could contribute towards the aim of achieving low-energy buildings for 2030 through establishing a set of appropriate design approaches to inform future domestic building design in Iraq, which can both enhance comfort levels and decrease energy usage while remaining culturally responsive. The low cost of energy led to the disregard of energy-efficient design practices. The thesis acknowledges that because of the subsidized energy prices, individuals depend on using air conditioning as the main cooling source in buildings. This has discouraged architects from designing buildings that make the best use of passive design in hot seasons, which are the dominating season of excessive energy use in Baghdad buildings. This research could persuade the government to enforce an appropriate energy efficiency policy. The thesis acknowledges that the cheap energy supply and more widely available electricity has led to many new air conditioning applications. Intrinsically, the provision of thermal comfort became the responsibility of mechanical systems rather than the building.

1.6 Structure of the Thesis

The thesis overall structure takes the form of eight chapters including this introduction. These represent the main parts of the research: the introduction; the literature review; the

research methodology; surveys analysis of the results, discussions; and finally the conclusion and recommendation.

Chapter One: Introduction

This chapter presents the introduction, providing a background for the research as well as the research gap. In addition, this chapter presents the main aim and objectives and establishes how this work will achieve them, providing links to the proposed research methodologies.

Chapter Two: Literature Review

This chapter reviews of previous literature in order to understand the gap in the field of study and develop awareness of the problem.

Chapter Three: Methodology

This chapter presents the research methodology used to gather and evaluate data to address objectives 1-4.

From objective 1-4, propose a framework for design strategies for new housing units in Baghdad, as a case study, which will require combinations of contemporary technology with passive design fundamentals in order to provide better and naturally welcoming housing solutions that are able to satisfy the functional expectations as well as the social needs. *(Objective 4)*

This range of objectives requires multiple methodological approaches including quantitative and qualitative methods. A combination of bioclimatic analysis, and analysis of questionnaires with mainly quantitative responses and qualitative interview responses were carried out to provide better and naturally welcoming housing solutions that are able to satisfy functional expectations as well as social needs.

Chapter ***Four: Bioclimatic Analysis Using Psychrometric Chart for Baghdad***

This chapter responds to ***objective 1*** of this research. It studies, analyses and identifies feasible passive strategies for application in Baghdadi climate.

Chapter Five: Public Survey Analysis and Perception

This chapter responds to ***objective 2*** of this research. It examines levels of householders' (public) satisfaction with both contemporary and vernacular houses with regards to the

environmental and cultural performance using a combination of questionnaires and analysis of the responses.

Chapter Six: Experts Survey Analysis and Perception

This chapter responds to ***objective 3*** of this research. It engages with professionals in order to understand their ideas on designs and construction in terms of passive designs of modern housing units in Baghdad, for example, academic, government and private sector. It uses a combination of questionnaires and analysis of the responses.

Chapter Seven: Discussion: Design Strategies for Future House in Baghdad

This chapter will present the evaluation of the findings of the literature review, climatic analysis, public survey and experts survey to achieve ***objective 4*** of this research. The aim is to establish sets of appropriate design approaches for new housing units in Baghdad, as a case study, involving different theoretical and empirical investigations in order to provide better and naturally welcoming housing solutions that are able to satisfy functional expectations as well as social needs.

Chapter Eight: Conclusion and Recommendation

This chapter presents the conclusions in response to the research aim and objectives which have been achieved by this research. The researcher makes further recommendations for future work in this field.

Chapter 2

Literature review

Chapter 2

2.1 Introduction

The consultation of diverse sources of academic and grey literature has been conducted throughout the progress of this research. This chapter reviews the available previous literature in order to understand the gap in the field of study and develop awareness of the problem.

In this chapter, section (2.2) and subsection (2.2.1) will focus on the discussion of theories, studies and strategies of existing literature associated with the conservation and consumption of energy of buildings in hot climates. The review then, in section (2.3) and subsections (2.3.1, 2.3.2, 2.3.3, 2.3.4, 2.3.5, 2.3.6, and 2.3.7), will focus on the general picture of sustainable development and its relation to sustainable architecture and building construction. After the review of the general picture, the link between sustainability and bioclimatic design has been carried out to improve thermal comfort by using the thermal features of the building energy efficiency strategies such as such as orientation, building envelope, building materials, energy efficiency, ventilation, and functionality, and so on, are presented. This will lead to an in-depth understanding of bioclimatic design by addressing new techniques as well as old techniques from vernacular architecture. These areas are seen as the main building blocks for delivering environmentally sustainable building designs. Sustainable building design elements and passive indoor climate control are largely considered to be synonymous; while passive systems can provide at best building integrated support to active air conditioning systems; reduce cost and energy used in such systems. A good passive climate control design is when a desired stable indoor climate is created due to the hygroscopic and thermal properties of the various design features in the building. Isolating and analysing the physics of existing systems in the building helps conclude whether the systems are able to create an acceptable living condition as determined by the various codes and standards.

Moreover, the section (2.4) and the subsections (2.4.1, 2.4.2, 2.4.3, 2.4.4, 2.4.5, 2.4.6, and 2.4.7) present the historical natural and cultural background of Baghdad, as a case study, and how architecture design in this context has responded to 21-century conditions and social values.

As a result, this section aims to establish the extent to which vernacular and contemporary houses have been designed to fulfil inhabitants' needs. Resident needs will be discussed in terms of environmental and sociocultural factors, as well as to consider architectural factors.

Through this literature review, the gaps in knowledge that have led to a reduced adoption of energy-efficient design in the Middle East countries has been established, with the main focus on the status of Iraq, Baghdad city.

2.2 Worldwide Issues: Energy use dilemma

The buildings we occupy affect our lives profoundly. We spend more than 90% of our time inside buildings, and they impact our healthiness, happiness, as well as the sense of well-being (Council UGB, 2016). The energy we use inside them also contributes significantly to global carbon emissions.

The most recent data from IEA on this topic was reviewed in 2020 based on data up to 2013. It is recognised that significant economic, technical and political developments have happened since the latest data. According to IEA, buildings utilise more than 40% of the overall energy usage, globally (IEA, 2017; IEA, 2013a; IEA, 2013b). It is also known that around 30 to 60% of this energy usage is used for enhancing thermal comfort levels in dwellings (AEEERS,2014). It is worth mentioning that the consumption of energy in a country depends on its policies, culture, and local climatic conditions. As a result, it may not be appropriate or suitable to design buildings in the same manner for different locations. This is because every location and place may have a different kind of climatic condition. In addition, factors which may vary between places include the culture, policies, economies and the availability of raw materials. Now, several developing countries as well as those which are developed are attempting to take into consideration the issue of energy conservation, especially in buildings. In addition, official policies, as well as standards, have been defined by some countries, discussing the bands for energy usage in domestic sectors, again based on the individual's needs and the location's policies, culture and local climatic conditions. Both architects and engineers use terms such as green buildings, eco-houses and low carbon energy buildings for proposing solutions to the current issues of global warming and climatic conditions. These kinds of

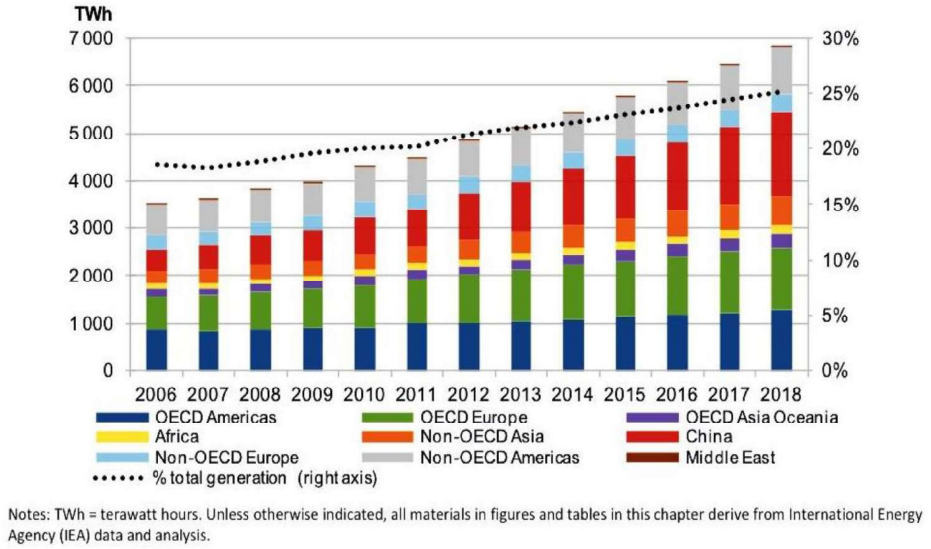
structures are a reflection of the choices on designs chosen for reducing the effects of constructions on the overall ecological balance. These structures can also contribute to a reduction in the operational construction costs by about 80%(Berardi, 2012). Applying integrated designs concerning low carbon energy usage can result in improved energy performances as compared to the traditional ways (EU, 2009). To elaborate, low carbon energy buildings utilise energy efficient glazing and high-performance insulation along with decreased energy consumption for cooling and heating systems. They may also make use of renewable energy generation technologies, in order to reduce carbon emissions such as photovoltaic electricity generation, although such aspects are beyond the scope of this study.

Around the world, including in European, CO_2 reduction targets, as well as staged energy policies, are all in implementation (Košir et al., 2014; Schade et al., 2013). A survey in 2008 showed that the European countries identify low energy domestic homes in a number of various descriptive terms. These included energy-positive homes, energy-saving homes, zero-energy homes, low energy homes, high-performance homes and passive houses (McLeod et al., 2012). Literature can also be seen to use the terms greenhouses, eco-houses and ultra-low energy houses for referring to such homes (EU, 2009).

Currently, based on the desired levels of sustainability, a reduction of 30 to 50% is needed in energy usage in proposed designs. Based on the several regulations and different climatic conditions globally, terming a low energy house is a complex process (Abergel et al., 2017; EU, 2009). For example, in Austria and Germany, the yearly energy usage in a low-energy house must be lower than the 40 to 60 kWh/m². Whereas, in France, the yearly energy usage in a low energy home needs to be under 50 kWh/m². Moreover, certain nations such as the UK are targeting zero carbon buildings. Nevertheless, it is worth mentioning that definitions and perceptions of low energy developments may vary from country to country (Abergel et al., 2017; EU, 2009). For instance, in the USA, the "Energy Star label" is received by homes which consume 15% less energy than the proposed energy usage by regulations (Abergel et al., 2017; EU, 2009).

Excessive consumption of non-renewable fuel resources is a chronic problem today, one of the causes is the continuous increase in demand for energy. As shown in Figure (2.1,

2.2), a continuous rise in production with most of the energy (81%) coming from fossil resources for instance natural gas, oil and coal, which are limited fuel resources.



Notes: TWh = terawatt hours. Unless otherwise indicated, all materials in figures and tables in this chapter derive from International Energy Agency (IEA) data and analysis.

Figure 2.1: *The total energy production (data from EIA,2018)*

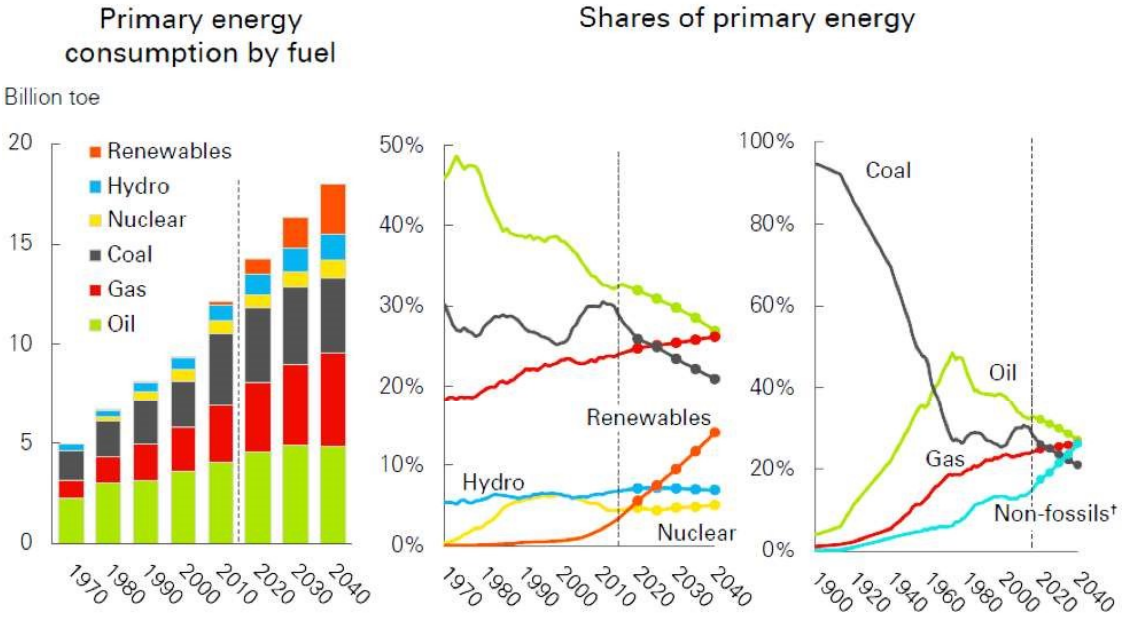


Figure 2.2: *The global energy mix (data from EIA,2014)*

A large part of this energy accounted for by the building sector, as shown in Table (2.1), with the sector consuming about 30% of the total energy in developed countries like the USA and the UK (references? EIA, 2014?). This is above the world average (23%), with the residential sector accounting for the two-thirds (Abergel et al., 2017). This means

developed countries like the USA and the UK currently consume more energy in the housing sectors than the rest of the world. However, based on Annual Energy Outlook 2014 analysis (EIA 2014), the rate of growth in energy consumption in this sector in developed countries is slower when compared with other countries; this is because developed countries are more advanced in applying energy-saving technologies as well as due to their policies and measures regarding energy management in buildings. Thus, this will differently change the picture in the future, where undeveloped countries will have higher energy consumption in residential sectors (Fig.2.3).

Table 2.1: *Percentage of energy utilization in building structures*

Country	Ratio	References
USA	33%	Zhai (2006)
China	30%	Yang and Li (2008)
European Union (EU)	37%	Pérez-Lombard et al. (2008)
UK	39%	Pérez-Lombard et al. (2008)

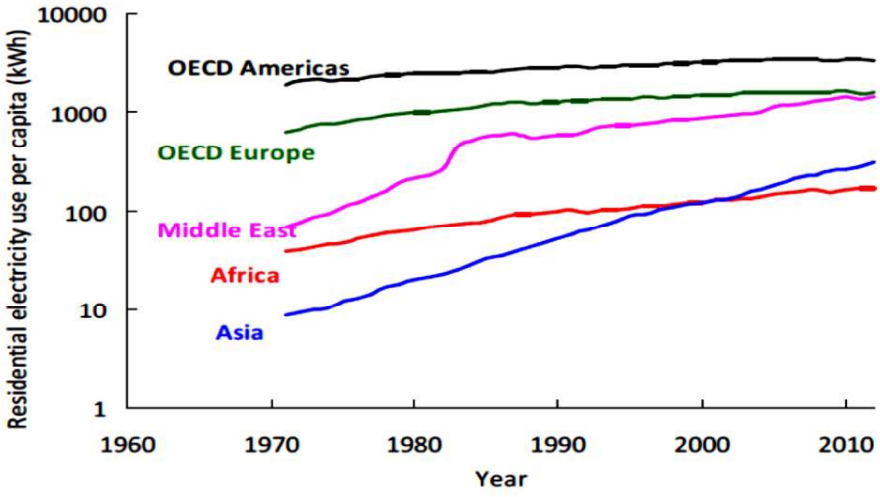


Fig.2.3: *Per capita housing electricity usage in several areas since 1971 (IEA, 2014).*

Many of the undeveloped countries (also known as less or least developing countries), as classified by the ((CIA) and O.P.A. (2008)), founded in areas with a hot, arid climate as identified by Saini (1980) (Mousli and Semprini, 2016), and shown in Figure (2.4). This climate is characterized by clear skies with strong solar radiation, which causes a high

daytime air temperature, and a wide diurnal range that makes the night relatively colder. The air is dry in such a climate, and the rainfall is usually limited to a brief period during the winter.



Figure 2.4: *The areas with hot arid climate (in yellow)*

(Researcher depend on Saini, 1980)

This climate usually causes overheating in buildings (Szokolay and Brisbin, 2004). Indeed, 40% to 70% of domestic energy supply in areas with such a climate is typically used in air conditioning systems for cooling purposes (Howarth et al., 2020; Lundgren-Kownacki et al., 2018; Abdullah, 2016). This means air conditioning is the major factor in building energy consumption and thus, an appropriate objective in building design in this context should be to cut or limit the use of such systems.

Furthermore, the problem is not only in consumption of non-renewable resources but also in its negative impact on the environment, representing an increase in the carbon concentration in the atmosphere, which causes global warming and climate change. This problem is particularly important in areas with hot, arid climate due to the vegetation in such areas are being limited because of the shortage of rainfall and the absence of

moisture. This means the surrounding natural environment can't absorb the CO2 released from the buildings. Middle Eastern countries are a good example of such a problem as most of their lands are empty desert while simultaneously having the highest CO2 intensity according to Global Energy Statistical Yearbook (2019). As global warming increases the air temperature, this will in turn increase the needs for air-conditioning, requiring more energy. This is shown in the work of Radhi (2009), which predicted that energy used for cooling houses in the UAE will increase by 23.5%, over the next few decades, because of global warming.

This will all lead to a closed circle, where fuels need to generate energy that will consume release in air-conditioning systems and CO_2 as a byproduct, which, in turn, will raise the air temperature and thereby increase the use of air conditioning systems and release more CO_2 and consuming more fuel.

As such, it is necessary to identify and promote approaches that reduce the usage and reliance upon air-conditioning machines in the domestic sector in areas with a hot and arid climate, like the Middle East, as this will save both energy and the environment.

2.2.1 Energy efficiency in Iraq: Baghdad as a case study

Iraq has an economy based on its oil exports thus making it an oil-rich country, which exports oil to other nations. In addition, Iraq is known to have an increased consumption of energy along with CO_2 discharges. This is because of the country's extreme weather situations which, alongside current typical building design and construction, make the use of air conditioners a must. Further, analysts and researchers have predicted that in the upcoming future, if residents do not change their lifestyles, then there will be even higher levels of energy consumption in the country. This usage of energy in the form of electricity rose significantly in the last twenty years (Minister of Electricity. Iraq, 2019). To elaborate, it was in the early 90s, when the energy crisis began in the country. This was mainly because of increased demands for energy along with inadequate supplies. This was the consequence of the ongoing wars and political problems in the country which led to further stability complications in the country. From 1990 to 2003, an economic sanction was placed in the country. This deteriorated the generation of energy even more and resulted in supply shortages. As Abbood et al. (2015) mentioned, these problems are still

being faced by the residents in the country. Khadduri (2013) reported that electricity cutouts in the country normally range from 15 to 20 hours in a day. The solution is usually to use privately owned generators, which are fueled with diesel and gasoline (D.B., 2014). However, it is worth mentioning that this is not an appropriate solution and in fact results in the production of undesirable localized emissions that have a negative effect on the air quality as well as the national and global environment.

Figure 2.5 displays such a situation in Baghdad. It is an actual representation the picture of Iraq's streets where electricians have to work through bare wires that are connected to local generators. Due to political instability in Iraq, no government regulations are imposed and still no standards have been developed in connection to energy efficiency. Further, any progress done on this matter is very slow.



Figure 2.5: *A typical demonstration of how electricians are working in Baghdad with electrical wires (researcher).*

Baghdad, as a capital and one of the main cities for Iraq, is faced with the energy crisis from decades of bad management, poor policies, and the lack of proper planning for the future with energy demands approaching approximately 900 MW during 2009, rising from 750 MW in 2005, a rise of 20% in four years (Al-Waeely et al, 2014). Following the lift of the economic embargo in Iraq, this rise in energy needs are simultaneous to the enhanced qualities of lives (Parsons Brinckerhoff, 2009).

Statistical reports have shown that Baghdad's building sector, specifically, accounts for 4% of agricultural energy consumption, 6% of commercial usage, 13% offices, 29% industrial usage and residential usage for 48% (Minister of Electricity. Iraq, 2018; Al-Samarrae, 2005). Due to Iraq's harsh climate, about 70% of the yearly residential energy usage, in Baghdad specifically, accounts for 46% of cooling and 26% of heating (Abbood et al, 2015; Hasan, 2012). Comparing these figures to the yearly residential energy usage for lighting and other appliances' use, the latter only accounts for 5% energy usage. Hence, how energy is used in the country is quite visible and these statistics reflect on the most problematic areas in terms of energy usage (Abbood et. al, 2015).

Such increased usages of electricity in buildings poses a major risk and appears as a potential barrier in decreasing energy utilization. Also, in the developing world, it seems that a somewhat conscious attitude to energy is missing; and is considered to be the case for Baghdad. To elaborate, relevant bodies such as the Ministry of Electricity in Iraq mention that 53.4% of electrical energy needs of the country are by the residential sector (Minister of Electricity. Iraq, 2018). In addition, almost every domestic construction in Baghdad is dependent on an air-conditioner for cooling needs.

While Baghdad has an abundant source of solar radiation, the electricity needs are mainly met with the burning of fossils (Minister of Electricity. Iraq, 2018). This is because of the rareness of applications like solar photovoltaic cells (PV) in Baghdad and Iraq due to the lack of knowledge of such technologies (Chaichan and Kazem, 2018). At the end of the 1980s, the presence of the preliminary sign of green building applications in Iraq by the use of one of the green building solutions, which are renewable energies, used solar energy at the Ministry of Science and Technology complex. Furthermore, currently, in the country, there exist no adequate or mandatory building codes, regulations and rules guiding builders and designers to incorporate energy efficiencies in their works.

Nevertheless, by the researcher's own experiences, some concise standards and codes are present with the help of scientific communities that work for promoting sustainable development. Adequate codes would mainly involve principles and regulations for designing buildings to be energy effective through consuming less water and energy (Minister of Electricity. Iraq, 2018).

In the last 25 years in Baghdad, there has been a consequent rapid increase in energy demands, economic growth as well as increased population growth. Based on the Iraq Central Organization for Statistics and Information Technology, the populace of Iraq reached 40.41 million in 2018 and is likely to reach 46.7 by 2025. Baghdad, as a case study, reached 7.6 million in 2014 and it's likely to reach 15 million in 2025. Such a rise is expected to cause a continuing rise in corresponding energy needs as well for operating residential buildings, thus leading to increased environmental and economic costs.

Based on the Statistical information achieved from the Ministries of Housing and Construction of Iraq (2018), the number of buildings in Iraq is 1,492,932, which includes housing units, establishments as well as public buildings (Ministries of Housing and Construction in Iraq, 2018). The total number of housing units is 763,980, more than 58.7% of which are in Baghdad (Ministries of Housing and Construction in Iraq, 2018), see Table 2.2. It has also been predicted that the surface area of urban spaces in Iraq will be doubled by 2025 if the rate of population growth and urbanism stays as it is.

Table 2.2. *Number of houses in Iraq*

Iraq	Baghdad	Karbala	Najaf	Basra	Mosul	Erbil	Sulimania	Total
No. of housing units	448,287	127,738	101,033	50,237	0	20,321	16,364	763,980
%	58.7%	16.7%	13.2%	6.6%	0%	2.7%	2.1%	100%

Source: *According to Ministries of Housing and Construction in Iraq statistics, 2018*

According to the Ministry of Electricity (Minister of Electricity. Iraq, 2018), 109,720 GWY were sold to the domestic sector in 2017. The proportion of domestic energy is estimated to be between 48% and 53% of the overall retailed energy in terms of all subdivisions. In

fact, this number is rising yearly by about 7.2%. In 2010, it was estimated that 533 kWh of energy could be generated from one barrel of petroleum. Based on this relationship, 109,720 GWY of electrical energy would need 205,853,659 barrels. This amount would be just for the domestic sector, as mentioned earlier. Such figures are undoubtedly a clear reflection on the number of fossils which are burned yearly.

As fossil fuels are nonrenewable resources, their depletion can be expected with such increased energy demands. In addition, this kind of usage also results in the massive environmental pollution with increased emissions of CO_2 emissions. Nevertheless, one favorable prospect that can be projected from such numbers is the chance for investing proceedings from oil for reducing energy usage in the domestic sector. In fact, this can also assist in developing sustainable industries for the harsh and warm climate in Iraq, Baghdad in specific. About 300,000 housing units will be constructed soon in the city (Ministry of Housing in Iraq, 2019), which will have resulting energy demands. Hence, if the design of these housing units could be revised in accordance with the country's economic as well environmental states, then an environmentally conscious approach can definitely be adopted. This would not only result in environmental benefits but will also have economic advantages. This research seeks to provide guidance to the industry to inform just such environmentally conscious domestic design strategies.

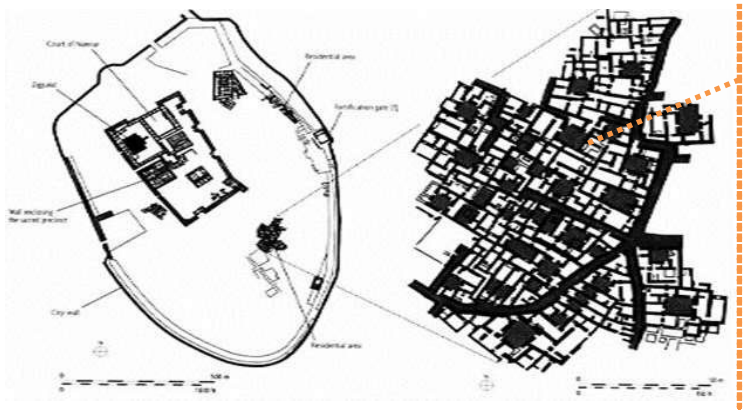
Based on the facts provided earlier, the current economic, energy as well as environmental states of Baghdad show that it is crucial for the city to take immediate response steps for reducing energy consumption along with increasing sources of income with the sale of oil. In addition, it is very important that the city and the country lower the corresponding CO_2 emission rates. To formalize these steps, an organized agenda must be planned initially for the culture and environment of Baghdad. This agenda could then offer solutions for the architectures in the city that can help in reducing the demands for energies along with providing specific rules for designing low-energy houses, that could then inform similar transforming practices across Iraq. This will be similar to other developing and developed nations which have worked on saving their energy produces by developing a low-energy, sustainable homes with the use of adequate and relevant standards and codes. In Iraq, such codes targeting the country's climatic conditions and cultural needs are needed for controlling the energy utilization and conserving fossils for

the upcoming generations (Minister of Electricity. Iraq, 2018; Ministry of Housing in Iraq, 2019).

As seen from above there is a problem with the increasing demand for energy, which is consuming non-renewable resources, and the resulting effect of this process on the overall environment. A large part of this energy is being used in the housing sector, primarily for air conditioning purposes in hot arid climates. The problem began in the twentieth century when scientific developments which made energy supply of electricity cheaper and more widely available leading to many new air-conditioning applications. Intrinsically, the providing of thermal comfort became the responsibility of mechanical systems rather than the building fabric, as was previously the case.

A solution could lie in increasing the efficiency of these systems. However, this would only be a temporary solution because the steady growth in world population will lead to a return to the same level of consumption or more. This means that the real solution lies in returning to the original functioning of the buildings. A building must not just provide spaces for the residents that are protected from the outdoor environment, but also provide them with thermal comfort by using natural resources and passive systems.

The vernacular building features and techniques in hot arid areas are a good example of such building fabric integrated approaches. For example, the vernacular house (in hot arid areas) is an ideal example of such features and techniques. These houses, built thousands of years ago, were found in the world's first town, Jericho, built in 7000 BC (Lay and Vance, 1992), see Fig. (2.6). The houses usually took the form of a courtyard house (inward-looking oriental house), this shape being preferable for structures in hot areas, as shown in Figure (2.7).



Ur: a housing sector in the southeast of the royal mausolea.
*The housing units were usually mudbrick, 1-story structures with many rooms in a central court. Windows were usually not present and no contribution to street architecture.
*Rich citizens resided in massive houses with several rooms in white-washed, 2-story buildings.

Figure 2.6.A: *Mesopotamian city: Ur, city plan and residential area. Source:LLynch, K. (1984).*

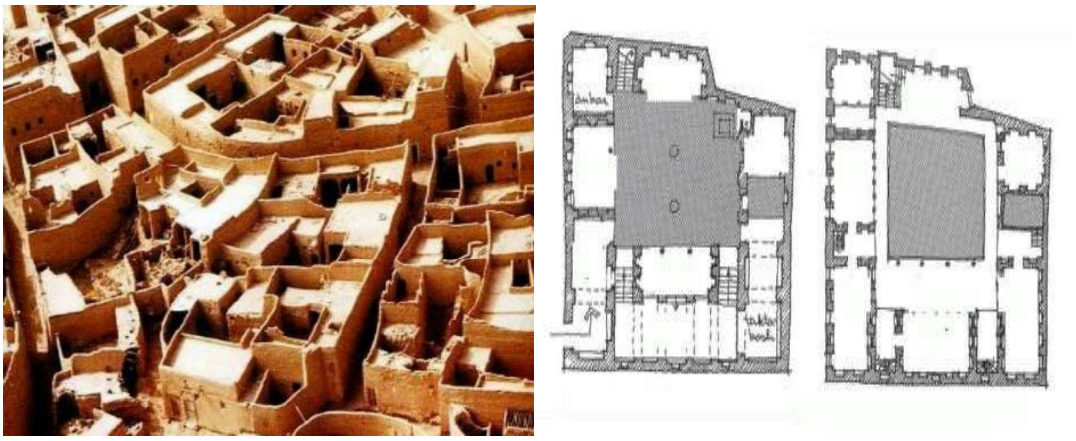


Figure 2.6.B: *Irregular plot and vernacular house in Baghdad (Source: Schoeauer, 2000)*

There is a strong belief that such houses succeeded in providing thermal comfort to their residents for many centuries. This belief is supported by the quality of civilization found in such areas, despite the harsh weather of such a hot arid climate. A good example of this is the civilizations found in Mesopotamia. Sigfried Giedion, one of the most important writers on the history of architecture, stated that "Mesopotamia is the birthplace of architecture" (Giedion, 1962) and there are many examples of building architecture to support this statement. One of these is the hanging gardens of Babylon (500 BC), which was the first green building to use green roofs for cooling purposes (Getter and Rowe, 2006). Courtyard houses were also found in Mesopotamia, used by Sumerians in 3000 BC (Edwards, 2006). The use of such houses continued during the pre-Islamic (dates) and Islamic era (dates) to the twentieth century when contemporary housing replaced them and the problem that is sought to be addressed here began.

Such vernacular houses used natural renewable resources like wind and vegetation to provide cooling through a process known as passive cooling (Givoni, 1991). In this process, during the day the house minimized the heat gain (i.e. by shading) and then, the colder air at night is used to purge this heat. Hot, arid climates have a wide range of daily temperature (section 2.4.2) and this makes the temperature of air at night relatively colder than the day, so the air could be used as a heat sink, wherein the heat gained in daytime was stored in the thermal form of the buildings. This process for cooling is referred to as night ventilation (also referred to as nocturnal convective or night cooling) and has been tested by many researchers (Cardinale, Rospi, and Stefanizzi, 2013; Priya et al., 2012). For

example, Givoni (1998) tested the effects of thermal masses on the thermal capacity of night ventilation. This study maintains that thermal comfort inside a high-mass building can be achieved even during a heat wave. To do so, it requires a house with enough thermal mass and sufficient ventilation during the night to remove the accumulated heat.

This process and other passive cooling approaches will be discussed later in depth in this chapter (Chapter 2, Section 2.4) of the thesis.

A return to courtyard houses could reduce energy consumption, but such a return is faced with many difficulties due to the loss of experience and knowledge needed to build such a house during the transition from vernacular to contemporary housing. Therefore, such knowledge needs to be regenerated by studying the designs of remaining houses and using scientific methods to simulate and optimize their designs; this could generate the information required to restart construction of such houses.

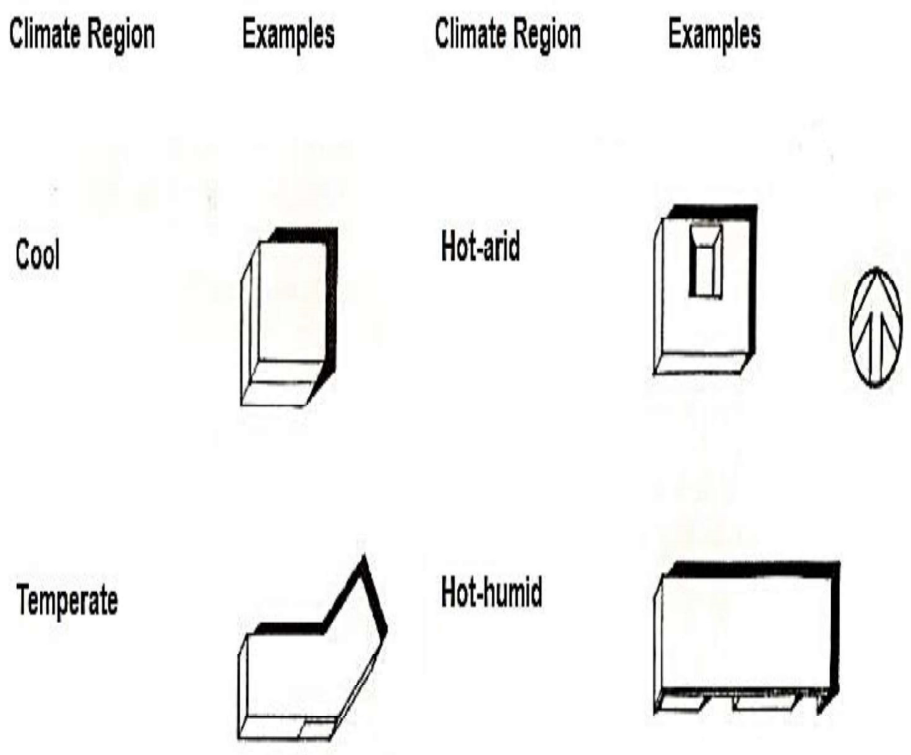


Figure 2.7: *Building shapes preferable for different climate regions, as shown by Egan (1975)*

The adoption of vernacular features and techniques in contemporary design would enable greater harmony to be preserved in design and architecture undergoing renewal. The physical, environmental, cultural, social and economic importance of vernacular architecture necessitates their regeneration, rehabilitation and conservation. In fact, it shows the importance of comprehending the approaches which could help in the conservation, rehabilitation and regeneration. Thus, the solution should start by studying the design of the vernacular design techniques and features especially the courtyard house and seek to optimize it. It is suggested here that an appropriate geographic location for such study would be in one of the cities of Mesopotamia, like Baghdad, because of the long history of the courtyard house in this region.

2.3. Towards sustainable design: Challenges & Opportunities

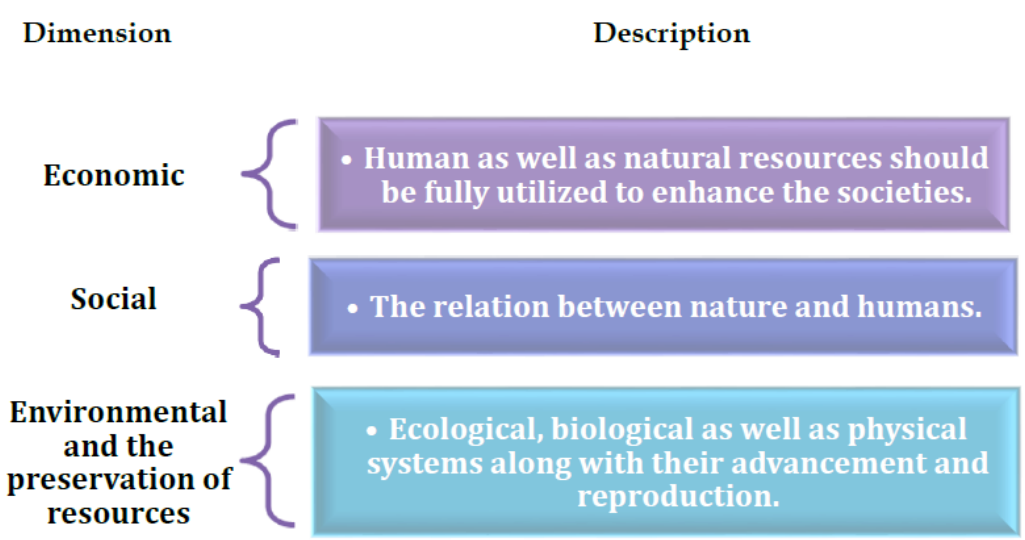
2.3.1 Sustainability

The term sustainability has come from the Latin word "substinere", (to hold; sub, up). In fact, "sustain" also means "maintain"\ "support" or "remain". The definition of "sustain" in the Oxford Dictionary is to cause something to continue for a long time. Also, it describes sustainability in terms of using a resource without causing it depletion or permanent damage. Sustainability has become a more common word since the 1980s, when it also began to be used regularly in relation to the living activities of humans without a negative effect on the surrounding environments. Therefore, if we apply it smeaning in the context of the modern use of the term "sustainability," it means maintaining the inhabitants of the earth for the current and the future. This promoted the adoption of the common meaning of the sustainability, which connected to the sustainable development concept by the United Nations Brundtland Commission on 20 March 1987 and formulated as: "Sustainable development is a development that meets the needs of the present without compromising future generations' ability to fulfill their own needs" (Brundtland, 1987). According to Chiu (2012), the meaning of sustainability in housing is: "the extent to which the environmental effect of housing activity is been reduced, so conforming to the levels within the capacity of the natural environment to carry, such that the environmental quality of the surroundings is improved to allow a healthier living" (Chiu, 2012). Under this regard, the daily living requirements of people include buildings through using

available natural sources such as a way that does not affect future generations' requirements of these resources.

Figure 2.7 (Edgar and Lahham 2008). show the three main dimensions in the fundamentals of sustainable development which are social, economic, and environmental factors, the environmental factor is considered to be the factor most closely linked to bioclimatic design and, thus, this factor is the focus of this thesis.

Figure 2.7: *The three main dimensions in the fundamentals of sustainable development.*



Source: Researcher according to (Edgar and Lahham 2008).

One significant step towards sustainable design rose with the launch in 1990 of BREEAM (Building Research Establishment's Environmental Assessment Method), the world's first green building rating method. Many other systems soon followed: LEED (Leadership in Energy and Environmental Design) in the U.S, GS (Green Star) in Australia, BCA Green Mark in Singapore, CASBEE (Comprehensive Assessment System for Built Environment Efficiency) in Japan, and so on (see Figure 2.5) (Doan et al.,2017; Vyas and Jha,2017; Strong and Burrows, 2017; AQUINO et al.,2013; Prum, Aalberts & Del Percio, 2012). Building environmental assessment systems are increasingly being adopted as de facto construction standards in countries without any formal building regulations. While adoption is driven largely by market pull, it is providing an effective mechanism for

reducing demand for energy However, concerns regarding compliance enforcement and quality have been raised. There's also a risk that the assessment process will become no more than a "tick-box" effort conducted by assessors who have become adept in manipulating the method of scoring. Even though these concerns are widespread, it is clear that the buildings' environmental assessment, building components, and construction materials are becoming the main factor for building designs, engineers, developers and occupants all over the world, resulting in beneficial changes and improvements

Early assessment systems primarily focused on the design instead of the actual "in-use" performances. This strategy risked intelligent design decisions being overruled by "chasing" credits from assessors, with little regard for the in-use performance. This has led to various examples of low energy-performing buildings, or poor user experiences certifying with high BREEAM or LEED ratings (Strong and Burrows, 2017). Most systems, however, now tackle this problem by certifying both the design stage and the in-use stage. The trend towards performance-based assessment is rising and the U.S. is taking new initiatives like the Green Building Council and Green Business Certification, Inc., will step up the trend toward concentrating on actual, rather than just theoretical, performance (Strong and Burrows, 2017).

Figure 2.8 show the timelines of the green building assessment systems development in worldwide. During the past 20 years, the green building assessment systems have gained remarkable traction. In 1990, the world's first green building rating system was developed in the UK under the name BREEAM. Many other systems have followed and started to increase in various countries with a variety of methods for evaluating green buildings in line with the climate, economic and social potential of each country. The key difference among different assessment systems is the weighting that they assign to various categories of the environment. These, of course, follow the region's key environmental and social issues, resulting in ranking systems designed to account for climate and local culture.

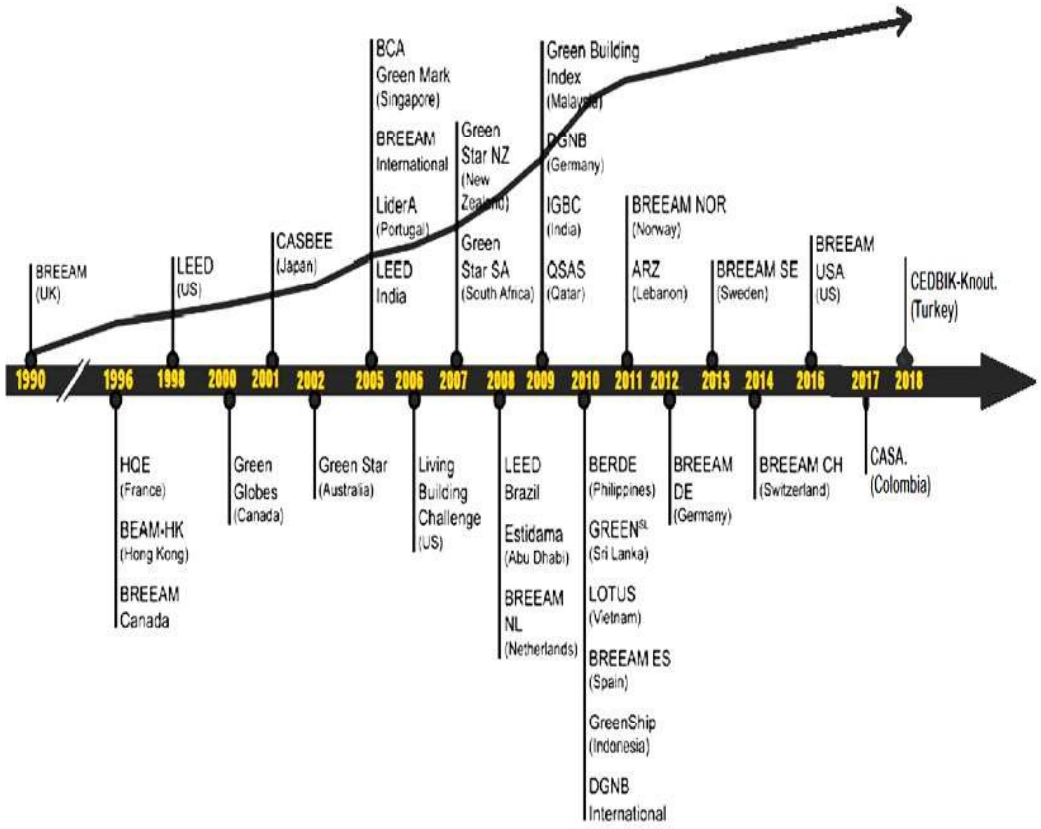


Figure 2.8: *The historical green building assessment systems development.*

(Researcher depend on Doan et al.,2017 ; Vyas and Jha,2017 ; Strong and Burrows, 2017 ; AQUINO et al.,2013 ; Prum, Aalberts & Del Percio, 2012)

Sustainability is also a synonym for "green designs", "bioclimatic design" as well as "high-performance buildings". Broadly definitions of these terms take account of the responsibility for the environment, resource efficiency, and occupants' comfort as well as a well-being senses. On the other hand, more narrow definitions could even focus on just one design feature, e.g. energy efficiency. Several of the additional clarifications about what constitutes sustainability, or green buildings, have been come from the LEED rating systems which are given by the Green Building Council. Sustainable building features, according to LEED, include developing sites with minimal effects on surrounding areas, utilizing recycled or the saved building materials, reducing water demand, providing energy without using fossil fuels, sufficient ventilation, minimising indoor pollution, and thermal comfort.

In the 1980s, a code was suggested by a committee of Iraqi code/Ministry of planning officials. The Iraqi code was based on British and American codes and covered only the design and implementation of constructions. In 1987, it was suggested that the code was to be optional for two years (Council of Ministries of Housing and Construction in Iraq, 2017). However, because the government did not ratify its adoption, Iraqi designers and engineers did not use it but instead have depended in their work on American and British codes for the last forty years (Council of Ministries of Housing and Construction in Iraq, 2017).

Incentivizing and implementing the retrofitting solutions that have been proposed in this study for designing houses across Baghdad will require complementary measures to be put in place. First, policies should be developed and enforced to encourage designers and owners to build their dwellings according to low energy design principles and requirements.

Future organization and enforcement of design policies are essential when low energy housing is adopted by Iraq's construction industry. It is important to create a funded institute to manage energy conservation in the construction industry (e.g. by business models). Research has provided comprehensive tools for the future organization of policies and solutions to establish guidelines for implementation to create a green, clean and low energy generation of buildings. Guidelines have been provided on low energy domestic designs for sustainable homes, for the supports of architects and civil engineers designing low energy homes in Iraq. Hence, the outputs of this study will support future organization.

2.3.2 Sustainability and bioclimatic design

The construction's environmental impact, minimising energy consumption, recycling, and environmental-buildings have captured architects' and engineers' attention around the world (Kamath et al.,2019). Sustainable designs recognise the built environment is interdependent; it is a moderation and change in architecture design and responds to the apprehensions of the current era about the harmful impacts and human activities consequences on the development of a type of artificial environments; an environment

which 'meets present needs of humanities without disrupting the ability of the next generations to address their own needs (Redclift, 2005).

Sustainable design involves making buildings that efficiently use energy, lands, materials, and water resources; improving ecosystem health; and addressing indoor environmental health issues. Therefore, in line with the objectives of sustainable developments, the effect of buildings should be examined in various aspects and scales at different construction stages, from the starting of the project to the habitation and commissioning levels, so that constructed buildings have had the least negative effects upon the humans and the environments. Adopting a passive design in buildings is important; helping to reduce the long-term running cost of energy and thus less exploitation of energy and earth resources. Those suggested factors are (Cardinale, Rospi, and Stefanizzi, 2013; Priya et al., 2012; Singh, Mahapatra, and Atreya, 2010): site selection, building shape, building location and size, and construction material selection. Hence, such findings confirm the feasibility of using passive approaches in contemporary buildings (Molodin, 2016; Priya et al., 2012).

So these factors are seen as critical building blocks to deliver environmentally sustainable designs (Singh, Mahapatra, and Atreya, 2010). The next section discusses bioclimatic designs as a significant approach to achieving sustainability without recourses to artificial conditioning or energy resources.

2.3.2.1 Bioclimatic design

Bioclimatic design describes the climatic needs of human beings according to thermal comfort studies. If the bioclimatic architecture is the mean, the outcome is sustainability. New standards and definitions are emerging at the present time in relation to sustainable development. More commonly sustainability is discussed with references to the operation of natural systems, with particular references to ways in which natural sources are used and managed (Hyde, 2008). Over the past few decades, there have been several attempts to develop systematic approaches that utilize human requirements and prevailing climatic conditions during the early stages of building design. The attempts aimed at defining the appropriate building design strategies for a certain region. This systematic approach of the bioclimatic building design was first proposed by Olgyay in the 1950s (Olgyay, 1963). Olgyay method was based on an experimentally derived ‘‘bioclimatic

chart or psychrometric chart''. The psychrometric chart is used to analyze information about temperature changes, wet bulb and dry bulb, as well as the humidity (relative and absolute) of a particular location. The psychrometric chart could be used to interpret the degree of comfort that the occupants can depend on and hence identify appropriate passive strategies for a particular climate.

Research into bioclimatic issues has taken the form of passive low energy architecture research and is carried out worldwide, with a well-developed field, as is evidenced in the passive and low energy architecture (PLEA) conferences. The PLEA is committed to "the development, documentation and diffusion of the principles of bioclimatic design and the application of natural and innovative techniques for heating, cooling and lighting" (see www.plea-arch.org/). This research has led to the development of bioclimatic design strategies, which are used by design professionals as a starting point for designing with climate in mind. Such strategies mainly achieved through a specific method including the psychrometric chart. To use this method, the monthly climatic parameters of the region collected and then analyzed with the chart mentioned above to determine the appropriate design strategies and considerations.

This research study offers insights into setting up various design strategies for new residential units in Baghdad. The psychrometric chart was used in chapter 4 in this research to evaluate and analyze the climatic characteristics in the city of Baghdad using the methodology described in Chapter 3 (section 3.2.2). In this way, by collecting the climatic indicators and then analyzing the findings of the psychrometric chart, the appropriate design strategies are provided.

The next section will explain the influence of building design and the effects of thermal comfort.

2.3.3 Sustainability and thermal comfort

The term sustainability, in its broadest sense, is synonymous with "green" which indicates a holistic approach to the building's design. This concept includes visual comfort, thermal comfort, and measures for improving indoor air quality.

The environment which provides a soothing effect is referred to by the term "thermal comfort". In this kind of environment, people feel neither too cold nor too hot. In this

situation, people have zero discomfort (Nicol, Humphreys, and Roaf, 2012; CIBSE KS6, 2006). In this environment, people have full relaxation and peace of mind and this is evaluated through subjective evaluations (ASHRAE Standard 55, 2004).

In connection to thermal comfort, many factors are involved but the main factor is people's reaction to their environment. Sometimes, people state it is too hot or it is too cold. This means that there exists a heat transfer effect between the surroundings and their body, along with the air quality (CIBSE KS6, 2006). Thermal comfort levels depend on the following factors:

- **Air quality**: Inside the room, the flow of fresh air is must for pleasing environment as stale and stuffy air can create clumsy environment. The supply of fresh air removes odor and increases oxygen levels inside the room (CIBSE KS6, 2006, p5).

- **Air movement**: Too fast air or still air both are not good for humans. Humans tend to like cold breezes in summer but cold air in winter can cause dryness and skin irritation.

- Humidity: The role of humidity is very important as high humidity with high temperatures can create discomfort, and on the other hand, low humidity creates dryness in eyes and throat, which shows the importance of normal humidity for human comfort.

- **Temperature**: The level of activity sets the required comfortable temperature. In sports room of indoor games, lesser temperatures are required, as compared to people's sitting or reading rooms. Thermal comfort also depends upon worn clothing. A person wearing a casual shirt will feel comfortable at higher temperatures but a man wearing a coat will need lower temperature for comfort. The following method is better to adopt to achieve thermal comfort levels in houses, based on the "CIBSE guide A for Environmental design" (Table 2.4).

Table 2.4: *Suggested criteria for comfort in homes (CIBSE guide A, 2006).*

Building /Room type	Winter operative temp. range for stated activity and clothing levels*			Summer operative temp. range (air conditional buildings) for stated activity and clothing levels*			Suggested air supply rate/(L.s–1 per person) Unless stated otherwise	Filtration grade++	Maintained illuminance/ lux	Noise rating (NR)
	Temp./°C	Activity/met	Clothing/ clo	Temp./°C	Activity/met	Clothing/ clo				
Dwellings:										
bathroom	20-22	1.2	0.25	23-25	1.2	0.25	15	G2-G4	150	-
bedroom	17-19	0.9	2.5	23-25	0.9	1.2	0.4-1 ACH to control moisture	G2-G4	100	25
hall/stairs/landings	19-24	1.8	0.75	21-25	1.8	0.65	-	-	100	-
kitchen	17-19	1.6	1.0	21-23	1.6	0.65	60	G2-G4	150-300	40-45
living rooms	22-23	1.1	1.0	23-25	1.1	0.65	0.4-1	G2-G4	50-300	30
toilets	19-21	1.4	1.0	21-32	1.4	0.65	> 5 ACH	G2-G4	100	-

The high temperature is not only responsible for discomfort, but duration of high temperature is also very important in discomfort. To measure summer thermal performance, the temperature and duration must be measured accordingly. The duration is presented as a percentage of yearly inhabited time. Based on the "CIBSE knowledge series KS6", the standards for overheating in homes are listed in Table 2.5.

Table 2.5: *Criteria for overheating criteria of homes*

Dwelling space	Benchmark summer peak temperature	Criterion for overheating
Residing areas	28°C	1% annual inhabited hours over 28 °C Operative temperature.
Bedroom	26°C	1% annual engaged hours over 26 °C Operative temperature.

Source: *CIBSE KS6, 2006*

As mentioned in Chapter 3, Section 3.2.2, the software used in the present study incorporates the ASHRAE Standard 55- 2005 comfort model. The analysis with a psychrometric chart in this research, chapter4, is based on the selection criteria for the comfort model. This research use the charts based on the comfort indoor plot option of Climate Consultant 6.0. For the comfort model, different percentages are offered for the similar passive cooling and heating design strategies for every month of the year.

Psychrometric chart is developed for each season and should thus be analysed in accordance with seasonal changes. The results of the analysis in chapter four are intended to inform the design strategies being developed for Baghdad;

Figure 2.10 presents the psychometric chart for the city of Baghdad and shows that summer comfortable levels are around 25-31°C. While, in winters, the temperatures for thermal comforts vary from 18-22°C. Residential buildings can be used 26 °C as a standard, Figure 2.9, (Jasem, Yahya and Kharrufa, 2008). The analysis of psychometric chart of Baghdad will be discussed in details in chapter 4.

Summer

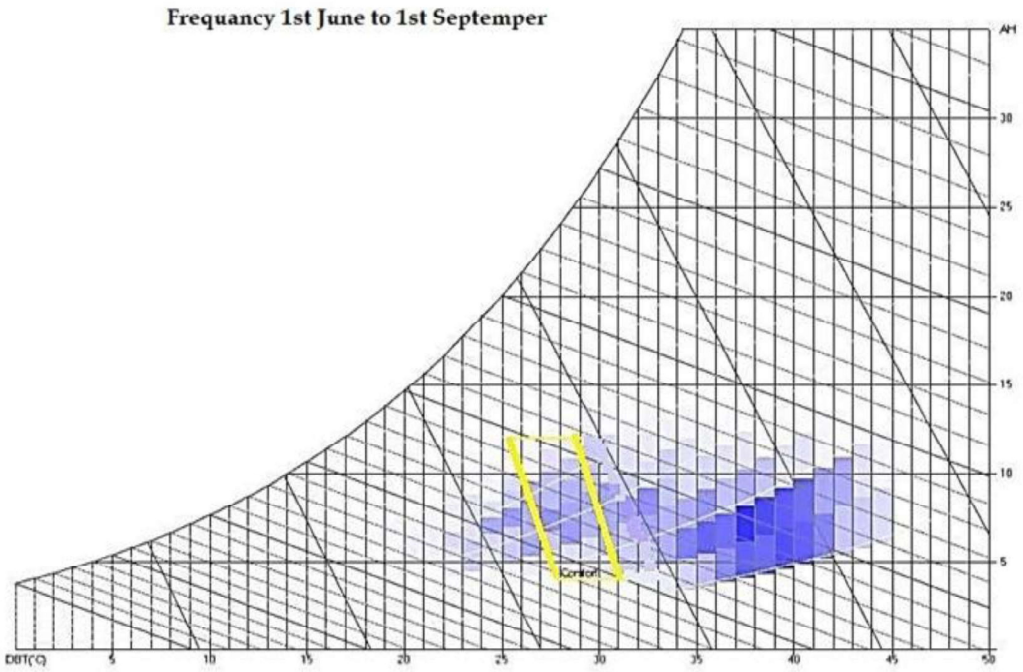


Figure 2.9:A : *Psychometric chart for Baghdad*

Winter

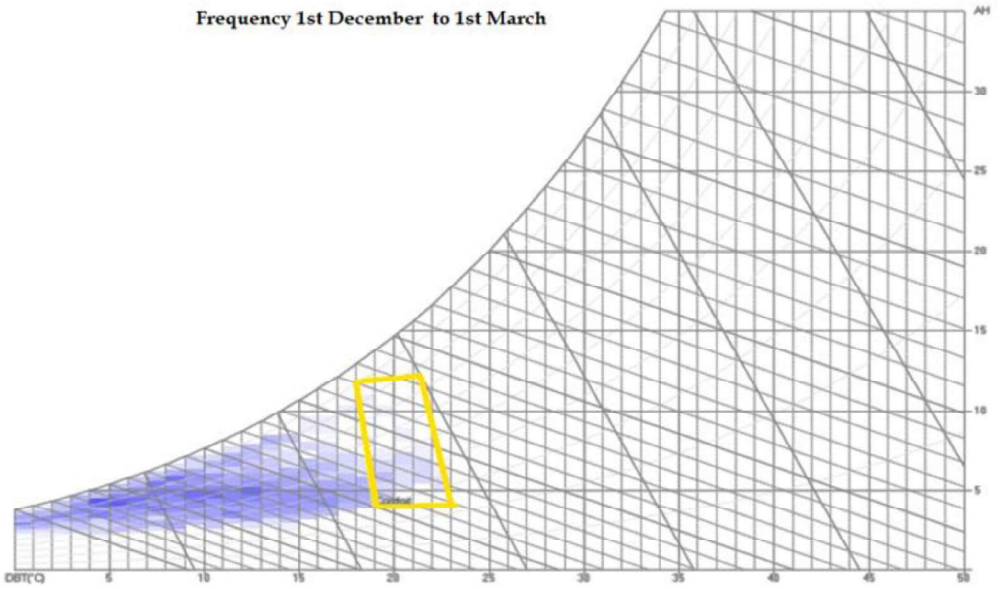


Figure 2.9:B : *Psychometric chart for Baghdad*

Nowadays, active cooling is in use by the installation of air conditioners as well as evaporative coolers to achieve thermal comforts (Kharrufa and Adil, 2008). To reduce cooling load and energy consumption in buildings could lie through increasing the efficiency of these systems. However, this would only be a temporary solution because the steady growth in world population will lead to a return to the same level of consumption or more. This means that the real solution lies in returning to the original functions of the buildings. A building must not just provide spaces for the residents that are protected from the outdoor environment, but also provide them with thermal comfort by using passive strategies; where vernacular building features and passive design techniques in hot arid areas may provide good examples from which to learn.

The adoption of vernacular features and techniques in contemporary design would enable greater harmony to be preserved in design and architecture undergoing renewal. The physical, environmental, cultural, social and economic importance of vernacular architecture necessitates their regeneration, rehabilitation and conservation. In fact, it shows the importance of comprehending the approaches which could help in the conservation, rehabilitation and regeneration. Thus, the solution should start by studying

the design of the vernacular design techniques and features especially the courtyard house and seek to optimize it. The next section will explain vernacular architecture as a significant approach to achieving sustainability.

2.3.4 Sustainability and vernacular architecture

Sustainability contributions to architectural designs are steadily increasing alongside technological developments. Although in today 's architecture, sustainability appears to be a new concept, in reality, it does not. That's because many of the principles of sustainable architectural designs draw on references to vernacular architecture and there are so many examples that architects may relate to in different parts of the world. When the world is looking for more sustainable buildings, revisiting the past is acceptable to understand sustainable features of vernacular architecture. It is clear how vernacular architecture has recognized and acknowledged that from a sustainability point of view matters to be studied and categorized.

Vernacular architecture exemplifies historical vision for the sustainability and low energy design to the local environment which incorporates the essence of environment architecture (Singh, Mahapatra, and Atreya, 2011). Vernacular architecture is rich with effective procedures and techniques to protect inhabitants from various and changing weather conditions to which they we subjected (Attia et al. 2011). Historically limited resources were available and with little opportunity to travel, local resources were used in the most effective way possible (Naciri 2007).

Vernacular architecture involves a natural invention of the interaction between environmental factors (location, topography, and climate) and cultural values (religion, tradition, and background). It reflects people's views of the environment as a living entity (Shanthi Priya et al.,2012; Singh, Mahapatra, and Atreya, 2011 Singh et al., 2010; Zhai andPrevitali, 2010; Oliver 1997; Abro, 1994; Fathy, 1986; Oliver1983; Warren & Fethi, 1982). Due to the lack of technology in the past, passive heating and cooling strategies were used. These were based on available resources and a variety of criteria such as orientation; form and local materials. A view that emerges at different levels in both urban planning and architectural design shaped by the beliefs and actions of occupants who have committed as a way of life with social ideals (Ragette, 2003; Foruzanmehr, 2017; Engin et al., 2007; Coch, 1998; Fathy 1986). Communities have learned from experience

that their welfare is fundamentally dependent on maintaining harmony with the surrounding environment (Fathy 1986) and that knowledge derived from vernacular architecture can provide the basis for the development of a low energy design (Singh, Mahapatra, and Atreya 2011).

There have been a series of studies from different countries and climates zones aimed at proving scientifically that the features of vernacular architecture are relevant and feasible today. For example, those of Foruzanmehr (2017, 2015, 2012, 2011, & 2008), Shanthi Priya et al. (2012), Singh, Mahapatra, and Atreya (2011), Zhai and Previtali (2010), Singh et al. (2010), Engin et al. (2007), and Martin (2004), discuss in particular the advantages and effectiveness of the use of vernacular techniques for improving energy efficiency.

However, the majority of contemporary buildings across the world do not respond to the environment, often buildings that are air-conditioned and make use of concrete and glass. It is now imperative to mitigate climate change and promote sustainable development that architects must design buildings with considering both, the environment as well as the energy consumption (Ayyash, 2015; Bell, 2008). Presently, the design for sustainable constructions is a big challenge which is faced by most of architects. The architects across the world have adopted new procedures, methods, and use of innovative technology from the late half of the 1980s for developing designs for sustainable buildings (Bell, 2008).

The vernacular design provides a paradigm for the interaction within climatic conditions and architecture, that is also shaped by resource availability driven pragmatic choices. Passive design techniques used in vernacular designs and refined over generations for environmental adaptations are especially relevant to the challenges facing contemporary design currently.

Passive design is a conventional concept and has been a key factor in building design since building structures were first introduced by humans. The local climatic conditions were a major consideration for the survival of the structures. The regions that experience harshest climatic conditions such as hot, dry areas of the middle east and extremely cold winters of the American northeast are a classic example. The passive design utilizes natural processes instead of active systems that reduce energy consumption. However, it's not possible to apply all the strategies mentioned here. The logical solution is to adopt the most appropriate strategies to efficiently decrease the carbon footprint of the building.

The efficient and intelligent implementation of few passive designs can yield impressive results where the buildings show optimal performance, Figure 2.10.

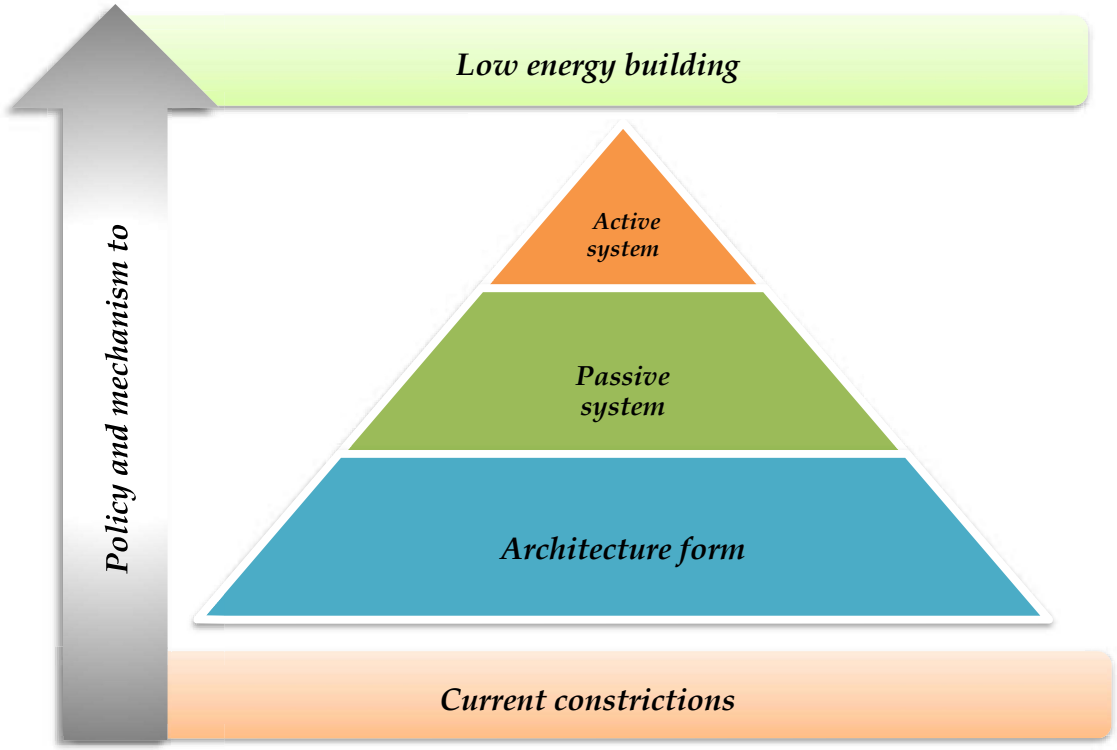


Figure2 .10 : *Low carbon building hierarchy (Researcher)*

Figure 2.10 shows that for future designs it is important to consider passive systems as well as architectonic forms for reducing reliance on active systems. This idea was supported by a number of studies on vernacular buildings and their thermal performance. These studies showed that such buildings attained adequate thermal comfort levels through most of the year with just the use of passive approaches. Also, it was found that indoor temperatures remained almost constant in some cases (Cardinale, Rospi, and Stefanizzi, 2013; Priya et al., 2012; Singh, Mahapatra, and Atreya, 2010). Hence, such findings confirm the feasibility of using passive approaches in contemporary buildings (Molodin, 2016; Priya et al., 2012).

Therefore, a blend of traditional aspects with modernization must be pursued in the future definitions of architecture and design. A hybrid system must aim to include traditional design techniques and allow for the evaluation of functional concepts and new aesthetic features (Kimura, 1994; Abalos, 2009). It would be a mistake to ignore the

technological potential, as well as knowledge, which exists today when aiming to achieve high-performance, sustainable buildings (Leatherbarrow and Wesley, 2009).

2.3.5 Towards an integrated sustainable design

Vernacular architecture has the strength to meet people's physical and spiritual needs, from the single-family to society in general. Physically, it reflects the century's worth of learning, in aspects such as climate, orientation, construction materials, and building techniques. Spiritually, in all its every day as well as seasonal activities, a sustainable building design harmoniously aligns with the lifestyle, uniting socio-cultural and people's religious expectations as well as society. Additionally, needs and requirements based on social attributes such as identity and their interaction with the environment may influence their self-projection in the environment. The flexibility idea and the traditional way of working help to apply the essence of vernacular design architecture to the contemporary era. Viewing in it a way out for the problems and issues of our building sector, vernacular design strategies and their associated cultural relevance's could start to inform the production of architecture and urban planning processes that would accommodate time and place. The limitations set by local resources and the unique characteristics allowed by the development of local building technologies results in sense bale and innovative forms and design techniques that are sustainable by essences and culturally adaptive (Motealleh rt al. 2018). So the relationship and identification between human behavior as well as the urban environments are what becomes important (Zhai and Previtali 2010). In general, the role of identity and culture, also in contemporary and future architectures, have not always been clearly defined in the socio-cultural related literature of design sustainability. Vernacular architecture and the change in the art of building from old to new, its process, and reasons are not often discussed. The tangible aspects of vernacular architecture and its environmental-related topics are increasingly undertaken in research studies. Nevertheless, there remain gaps within the efficient synthesis of non-tangible criteria like historical developments, socio-cultural aspects of vernacular architecture. Those intangible parameters aren't regularly acknowledged and appreciated, mentioned or studied (Elkadi et al. 2008; Kultur 2012). The question about the reasons for the decline of vernacular traditions is important to ask because it leads to the better understanding of the modern use and meaning of such traditions. However, instead of searching for such a

single ideal technical pathway, it is essential to learn to identify also listen to the number of voices that strive to frame the debate and the concepts of alternative sustainable places that people express.

The study of vernacular architecture presented in this section are arise three key issues. Firstly, research often focuses on vernacular architecture's technological, environmental performance, and overlook to concern its self with socio-cultural sustainability. As an approach, the essence of sustainability lies in achieving both developments and balances (Qtaishat et al. 2017). Secondly, the interlocking of those dilemmas of identity, modernity, and sustainability has directed to the point that modern as well as future architecture could not go without being sustainable not just physically, but also socio-culturally, economically, and regarding relevant interlocking terms, ideas, and fields. Finally, given the different and interlocking areas associated with vernacular architecture in the global circumstances, vernacular architecture techniques or technology-based work remains generally limited to performance-based examples (e.g., Motealleh rt al. 2018; Halicioglu 2012; Zhai and Previtali 2010 et al.). This limitation has caused by a few reasons: one has been deeply linked within the conventional ideas of vernacular and contemporary in architectural discourse, while the other the assumption is that architectural design is sustainable and integrable by default into modern architectures. This section of the research argues that all these issues are what caused a paradoxical circumstance, where vernacular design is abandoned and replaced by contemporary, even though academics criticise these as a source of the sensitive, sophisticated, and intelligent environmental designs. Eco-cultural approaches could emphasize the reorientation of values to engage environmental and socio-cultural issues (Qtaishat et al., 2017). The ideal issue here is the idea that sustainable buildings must be more and more fully related to the concept of local area and place. First, it draws inspiration from its environmental concern and revives vernacular concepts of houses beside a focus on relearning the sense of place.

Subjectively, this unique sense of identity emerges from within nature as well as its local characteristics. For instance, the climate is being considered as a determining factor for sustainability and regionalism in architecture. This latter view generally derives from the belief that regional architecture is shaped by climate conditions in the past. The continuity of meaning among both tradition and the individual's people, combined with the local conditions, is thus addressed. The eco-cultural approach, as a design strategy, also draws

inspiration from the approaches of indigenous and vernacular buildings. These vernacular building served as indicative of the way in which rooted cultures have naturally evolved appropriate. This approach can help develop more social constraints of vernacular and contemporary, concepts, evolution to better understand this process of integration. They could also help generate contemporary sustainable designs and constructions.

This research furthermore argues that the sustainability of vernacular design is based on isolated performance criteria such as thermal comfort and energy efficiency. Socio-cultural factors could be more important than the actual environmental impact of particular traditions. Environmental and sociocultural factors interrelate in a complex, dynamic, and context-dependent way, which both make it challenging for identifying the extent to which particular factors play an extra deterministic part than others. During all circumstances, each factor needs considerations for the continuity of a particular nature of the traditional and sustainability challenges.

The next section will explain challenges in delivering sustainable building.

2.3.6 Challenges in delivering sustainable building

The application of the energy design strategies and regulations will be one of the most significant threats to sustainability developments of the Middle East due to the constitutions of the local area and the energy sector 's dependence on subsidised fossil fuel (Abolore, 2012; Ismael and Hussain, 2019). The application of the energy design strategy and regulation will be a relevant indicator of successful policies on energy efficiency design (Abolore, 2012; Aje, 2016; Baron, and Donath, 2016; Ismael and Hussain, 2019). The objective of the energy efficiency strategies and regulations in architecture could only be achieved through the efforts of all groups, including the construction industry, public, and governmental authorities on the energy performance of buildings, which would be appropriate for the climate of the Middle East countries. Consequently, the challenges associated with the expectations of different parties tend to prevent the application of the energy design strategies and regulations. Hence, in this research, a study will be conducted specifying the relationships among all groups regarding all these challenges to energy design strategies and regulations.

Various previous studies have addressed possible barriers to achieving sustainability. Listed below are the barriers to sustainable designs in the Middle East and Iraq which were identified as a result of the theoretical literatures viewpoints.

Table2.6 show the existence of four essential problems that are capacity / professional challenges, technological challenges, social challenges, as well as economic challenges, which need to put appropriate solutions for them.

Table 2.6: *The summary of challenges in delivering sustainable building in Iraq*

Challenges			Sources
Capacity/Professional challenges	I.	Poor knowledge of sustainable design	Zainul-Abidin et al.(2003) Baron and Donath (2016); Ismael and Hussain(2019)
	II.	Inadequate awareness and knowledge of the concept of sustainability and benefits within.	Abolore, (2012), Akbiyikli et al., (2009), Zainul-Abidin (2003), Aigbavboa et al. (2017); Ismael and Hussain(2019)
	III.	Poor understanding of the project objectives and requirements	Abidin et al. (2003), Babalola et al. (2015), Wai et al., (2012)
	IV.	Lack of knowledge and availability of alternative sustainable materials	Abidin et al. (2003), Baron and Donath (2016); Ismael and Hussain(2019)
	V.	Lack of related legislation and government support	Abidin et al. (2003), Opoku and Ahmed (2014), Ayarkwa et al. (2017)
	VI.	Incompetence of Contractor/Subcontractors	Abidin et al. (2003)
Technological and legal challenges	I.	Lack of modern Technologies	Babalola et al. (2015); Ismael and Hussain(2019)
	II.	Lack of technical know-how in sustainable construction	Aigbavboa et al. (2017), Babalola et al. (2015); Ismael and Hussain(2019)
	III.	The challenges transformation of intellectual and functional towards green buildings.	Aigbavboa et al. (2017), Babalola et al. (2015); Ismael and Hussain(2019)
	IV.	Lacks of the Green Law on design.	Alsanad (2015); Ismael and Hussain(2019)
	V.	Lacks of a locally appropriate method of green buildings assessing.	Aigbavboa et al. (2017), Babalola et al. (2015); Ismael and Hussain(2019)
	VI.	Private sector weakness in green buildings field.	Abidin et al. (2003) ; Alsanad (2015)
	VII.	Uncertainty about the performance of sustainable technologies.	Alsanad (2015); Ismael and Hussain(2019)
	VIII.	Sustainable technological operation misunderstanding	Babalola et al. (2015); Ismael and Hussain(2019)
	IX.	Lack of adequate green technology parameters.	Babalola et al. (2015); Ismael and Hussain(2019)
Design challenge	I.	lack of knowledge by architects, civil engineers, professionals, and other staff in the design, as well as the implementation of green buildings	Zainul-Abidin (2003), Aigbavboa et al. (2017); Ismael and Hussain(2019)
	II.	The intellectual and functional transformation difficulties to green buildings.	Alsanad (2015); Ismael and Hussain(2019)
Societal Challenges	I.	Lack of awareness by clients\publics	Djokoto et al. (2014) Opoku and Ahmed (2014), Ismael and Hussain(2019), Pitt et al. (2009)
	II.	Lacks of incentives from the government.	Aigbavboa et al. (2017), Babalola et al. (2015); Ismael and Hussain(2019)
	III.	Traditional construction resistance to change.	Alsanad (2015)
Economic Challenges	I.	Additional costs	Ismael and Hussain(2019); Baron and Donath (2016); Abidin et al. (2003)
	II.	Incremental times	Aigbavboa et al. (2017), Al-Yami and Price (2006), Lowe and Zhou (2003), Miranda and Marulanda, (2001)

Researcher depend on the literature

2.3.6.1 Capacity / Professional challenges: Capacity or professional challenges are associated with 6 variables (Table 2.6). Such issues may be exacerbated by poor knowledge of sustainable design, poor understanding of the project objectives and requirements, lack of knowledge and availability of alternative sustainable materials, lack of related legislation and government support, as well as incompetence of Contractor/Subcontractors.

Abidin et al. (2003), Baron and Donath (2016), and Ismael and Hussain (2019) recognized the lack of knowledge among construction practitioners on green technology and materials, which is considered as a significant challenge for the industry to implement green strategies and specifications. Although the building industry in the developing countries depends primarily on foreign workers, it has been evident from the research that there are lacks of the necessary experiences or expertise required to meet the challenge of all those with responsibilities in this sector in Iraq.

This issue significantly affects the cost-effectiveness of implementing sustainable building designs. According to Ismael and Hussain (2019), the need for effective regulations is to raise the baseline benchmark while the benchmark upper will be raised by market forces. A further major barrier to sustainable practices in the construction industry is the lack of green building regulations and assessment methods in Iraq (Ismael and Hussain, 2019) and the Middle East more widely (Abolore, 2012; Aje, 2016).

2.3.6.2 Technical and legal compliance problems: Legal problems are associated with 9 variables (Table 2.6). Such issues may be exacerbated by lack of modern technologies, lack of technical know-how in sustainable construction, the challenges transformation of intellectual and functional towards green buildings, lacks of the Green Law on design, lacks of a locally appropriate method of green buildings assessing, as well as private sector weakness in green buildings field, uncertainty about the performance of sustainable technologies, sustainable technological operation misunderstanding, lack of adequate green technology parameters.

A significant challenge facing the Iraqi construction industry is the limited availability of green materials and equipment in the local markets (Ismael and Hussain, 2019). An extra important challenge is the uncertainty of the performances of these products and

technologies among industry stakeholders, as well as consequently their cost-efficiency. These challenges raise the resistance among practitioners to support the changes from vernacular design to more sustainable building. Mahmoud et al. (2019) highlighted the importance's of green specifications as a vital factor for the success of sustainable building practices (Mahmoud et al., 2019). A crucial challenge for the industry is the lack of the formal building codes and standards in Iraq, according to Ismael and Hussain (2019), Professionals produce their designs according to their background or schooling, leading to wide variation of standards across Iraq (Ismael and Hussain, 2019).

At the end of the 1980s, the presence of the preliminary signs of green building applications in Iraq was indicated by the use of one green building solutions, renewable energies, with the installation of PV at the Ministry of Science and Technology complex.

Iraq's environmental movement is still in its infancy, with numerous pioneering sustainability projects ongoing. A crucial challenge for sustainable development is the lack of adequate sustainable solutions and technologies. It can be argued that the country currently lacks an appropriate framework for implementing green building projects. Experts and construction companies persistently promote the adoption and acceptance of green practices in both the public and private sectors in Iraq. The Iraqi Construction Industries need to take proactive steps to increase awareness and promote sustainable development in construction. Consequently, the construction sector should find itself responsible for its use of resources, as well as its environmental impact.

In the past, the public sector was involved only in building houses. But now, with the inclusion of government, private sectors are encouraged to play a part in building homes as well. The main initiative now is to construct houses that provide people with good opportunities and develop new solutions in light of the latest technologies and architectural designs (Iraqi Ministry of Construction and Housing, 2010; 2017; 2019).

To elaborate, the current situation shows that in order to reach the level of complete analysis a greater number of studies and researches are required. This research focuses on formulating possible design strategies for the country on which to build solutions.

2.3.6.3 Design challenges: Design challenges are related to only two variables (Table 2.6). They could be represented by the lack of knowledge by architects, civil engineers,

professionals, and other staff in the design, as well as the implementation of green buildings, as well as the intellectual and functional transformation difficulties to green buildings.

Sustainability is still a relatively new concept in most developing countries, including Iraq, (Abolore, 2012; Aje, 2016; Baron, and Donath, 2016; Ismael and Hussain, 2019). Many industry stakeholders, such as architects, developers, and contractors, do not realise the benefits of sustainable design; therefore, there is a limited drive for its implementation in the housing sector (Ismael and Hussain, 2019). If this is to change, so there should be changes in thinking, behavior, production, and consumption into the construction industry (Ofori, 1998:35). For example, Abolore (2012) attributed the low level of sustainability of construction projects delivered within the Nigerian construction industry, to the low level of awareness of the concept of sustainability among construction participants. While, Alsanad (2015) made a similar discovery when assessing awareness, drivers, actions, and barriers to sustainable design in Kuwait. Where it was observed that sustainable design implementation is low, and this can be a result of a lack of awareness of the concept within the country (AlSanad, 2015). However, Baron and Donath (2016) observed that the major challenge of sustainability implementation in Ethiopia is not that of awareness but appropriateness. It was observed that, while there was an awareness of the concept of sustainability, it wasn't implemented correctly. Either it was completely neglected due to budget constraints, lack of alternative building materials, either knowledge or it is reduced to the issue of sustainable resource management. These studies, hence, show that the understanding of the concept of sustainable design in its holistic form could be a major challenge toward achieving sustainable designing the Iraqi context.

2.3.6.4 Societal Challenges: Societal challenges are associated with 3 variables (Table 2.6). Such issues may be exacerbated by lack of awareness by clients\publics, lack of incentives from the government, and the traditional construction resistance to change. Most of these are due to the lack of strategies and planning in all social and economic sectors in future green building plans.

Public awareness of environmental problems is a crucial aspect of the implementation of sustainable building. From their market survey, Ismael and Hussain (2019) concluded that

while most clients in Iraq are aware of environmental pollution problems, they still view environmental protection as being the sole responsibility of the local government. As a result of this limited perception of responsibility in addition to the limited awareness of the costs and benefits of sustainable design, different players in the construction industry are resisting changing traditional construction methods and processes to more sustainable ones. Ismael and Hussain (2019), Aigbavboa et al. (2017), and Babalola et al. (2015); mentioned that the government's lack of adequate incentive schemes is another crucial barrier for the country's adoption of sustainable practices (Ismael and Hussain, 2019; Aigbavboa et al., 2017; and Babalola et al., 2015). Ismael and Hussain (2019) stated that public projects account for the largest share of the construction market in Iraq; therefore, sustainable application initiatives should start from the government (Ismael and Hussain, 2019). Since sustainable practices and technologies meanwhile are not competitive financially and economically, governmental support from policies to incentives is needed.

2.3.6.5 Economic challenges: Economic challenges are related with 2 variables (Table 2.6). Such issues may be exacerbated by the either real or perceived additional costs in the context of budget constraints. They could be caused mainly by the lack of financial allocations for the construction of green buildings, whether public or private.

There is no doubt that each design project's economic revenue is an important goal for developers and investors, and it is the essential considerations for decision-makers to achieve sustainable designs (Ismael and Hussain, 2019; Baron and Donath, 2016; Al-Yami and Price, 2006; Lowe and Zhou, 2003)

Ismael and Hussain (2019) identified in their market survey that there is a belief among building professionals in Iraq, that sustainable building design would increase the cost of construction projects without quantifying benefits; This perception poses a significant challenge; that is particularly evident in developing countries, as well as Iraq, because of the energy-efficient approaches, such as high-performance insulation protection and energy-saving equipment that have to be imported, could be raising the overall cost of the project (Shen et al., 2016). Ismael and Hussain (2019) identified other challenges that will affect the cost-effectiveness of any building projects in Iraq, such as the lack of green product demand and lack of government incentives (Ismael and Hussain, 2019). Miranda and Marulanda (2001) in a study of sustainable design in developing countries, posited

that a major challenge is a fact that it is being perceived as a concept that would add cost to the project. This idea is conceived without a critical evaluation of the whole-life benefits of sustainable design. A similar observation was made in the study of Aigbavboa et al. (2017) which assessed the sustainable design practices in South Africa. It was discovered that the foremost challenges are the assumption of additional cost to building projects, and limited understanding of the benefits of sustainable design. Lowe and Zhou (2003) pointed out that this assumption that sustainable design cost more, without proper evaluation, poses a big challenge in the adoption of sustainable design practices in most developing countries around the world. Djokoto et al. (2014) assessed the barriers to sustainable design in Ghana from the perspective of professionals within the built environment and discovered that lack of demand was a major barrier. Another aspect relating to economics, besides the cost, is the construction times that are considered to be a crucial performance criterion for construction designs (Aigbavboa et al., 2017; Al-Yami and Price, 2006; Lowe and Zhou, 2003; Miranda and Marulanda, 2001). Building delays often increase project costs and impact the reputation of all stakeholders (Aigbavboa et al., 2017). Since sustainable design requires the integration of green strategies and technologies with the other building components (Ismael and Hussain, 2019), there will, therefore, be dramatic delays if this is not considered throughout all project stages (Hwang and Ng., 2013).

The main challenges of sustainable design construction in the Middle East and Iraq, through the above theoretical viewpoints (Table2.6), show the existence of four essential problems that are capacity / professional challenges, technological challenges, social challenges, as well as economic challenges, which need to put appropriate solutions for them.

2.3.7 Benefits of applying energy efficiency design guidelines in domestic buildings

Buildings utilise more than 40% of the overall energy usage, globally (IEA, 2017; IEA, 2013a; IEA, 2013b). Given the availability of several possible solutions for significantly reducing the energy requirements of buildings, potential energy efficiency savings in the building sector would offer numerous benefits. Since the scale of energy use in buildings

is high, it will contribute positively to both national and global climate preservation, public health, and the conservation of the economic growth environment. Minimizing the consumption of building energy in the Middle East countries could be increased the amount of oil exported, which could positively reflect in the economy of the countries. Moderating the energy-end usage of buildings would also be reduced greenhouse gas emissions and pollution produced from fossil fuel combustion.

It is worth mentioning that the consumption of energy in a country depends on its policies, culture, and local climatic conditions. As a result, it may not be appropriate or suitable to design buildings in the same manner for different locations. This is because every location and place may have a different kind of climatic condition. In addition, factors which may vary between places include the culture, policies, economies and the availability of raw materials.

Now, several developing countries as well as those which are developed are attempting to take into consideration the issue of energy conservation, especially in buildings. In addition, official policies, as well as standards, have been defined by some countries, discussing the bands for energy usage in domestic sectors, again based on the individual's needs and the location's policies, culture and local climatic conditions.

Both architects and engineers use terms such as green buildings, eco-houses and low carbon energy buildings for proposing solutions to the current issues of global warming and climatic conditions. These kinds of structures are a reflection of the choices on designs chosen for reducing the effects of constructions on the overall ecological balance. These structures can also contribute to a reduction in the operational construction costs by about 80%. Applying integrated designs concerning low carbon energy usage can result in improved energy performances as compared to the traditional ways (EU, 2009). Energy-efficient buildings provide a more stable indoor climate, compared to vernacular buildings. Given that households use less energy for building-related usages, it is expected that doubling the potential would improve the environment as well as public health (Figure 2.11).

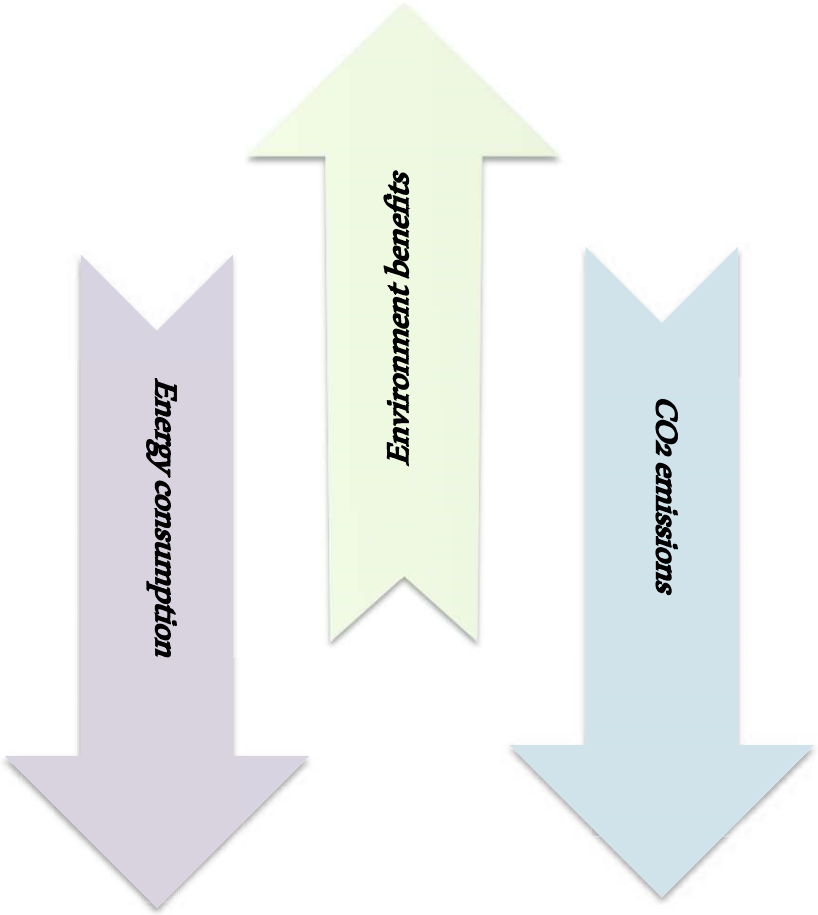


Figure 2.11: *The relation between energy consumption, savings, and CO_2 emissions (Researcher)*

Environmental benefits: Most non-renewable natural resources, like oil, coal, and natural gas, are expected to be consumed within a period of 40 to 200 years unless managed in a sustainable way (Ting, Mohammed and Wai, 2011).

In any country, the availability of natural resources would be reflected in economic growth and a better lifestyle (Panayotou, 2016). For example, oil has facilitated Iraqi's transition from rural scattered areas to a modern urbanised nation. Nonetheless, based on the current oil production and the reserves available in Iraq, the production will last for only 20 years.

Conserving and managing natural resources for the benefit of future generations is the essential concept common among all of the sustainable definitions available. Consequently, natural resource conservation could achieve through both the application and adaptation of the sustainable building industry.

Developing countries have the benefit of implementing sustainability principles and technologies when projects are under development (United Nations, 2013). Iraq as an example of a developing country that would benefit from the natural resources of the country in the future if it endeavours at this stage to apply sustainability to the built environment. The advantages earned would include reversal of the deteriorating air quality in urban areas, lower energy demand, and use despite the growth of regional population as well as positive impact on economic development, concerns regarding safe drinking water supply due to freshwater scarcity, waste management, industrial pollution, coastal pollution, along with subsequent stress on marine ecosystems.

Energy conservation impacts on building design: A building's architectural design is the concept under which it would operate and function, and so the better the design for the building's functionality, the better the outcome. Considering the building's energy consumption in the design throughout the early stages, along with their multidisciplinary aspects, constitutes the architect's work process. The process of architectural design, and more essentially the early design stages, embraces significant opportunities to achieve low energy buildings. The essential principles, influencing the performance of the building, are addressed during the early design stages.

Tasks, such as finding form, should also include aspects of environmental performance and energy usage, for example, layouts, aesthetic, and natural ventilation. Accordingly, to achieve more energy-efficient design, the spaces sizes, layouts, orientation as well as opening sizes should be taken into account. Moreover, with regard to the low energy design, construction materials should be considered in the design to enhance the building performance. Adoption of properly available sustainable materials should be included in the building's total energy budget.

Energy conservation impacts on building materials: A building consists of a building envelope includes external walls, partition walls, and a roof that separates the inner

spaces. The building envelopes provide an essential barrier to outside climate extremes. It offers filtering, which sufficiently modifies the climate to make internal conditions more acceptable. That acts being a passive modifier to external climate, depending on the properties of each material and how their arrangement affects the interior conditions (Dodo et al., 2011; Hamza and Greenwood, 2009; Collier, 1995). Building materials, therefore, need to be carefully selected to provide comfortable conditions in the interior of the building and assist in reducing the building's energy consumption. In a hot climate, especially Baghdad as a case study, therefore, the most efficient passive strategies for the whole year in Baghdad are solar shading of windows, natural ventilation, and direct evaporative cooling.

Feasibility of low energy domestic buildings in the Middle East: The application of low energy design measures in dwellings will reduce the total cost of the building's lifecycle. Low-energy buildings could achieve an operational energy reduction of up to 70 percent, which would contribute positively to the savings of the building's total cost (Yang et al., 2014). Furthermore, energy-efficient housing design provides environmental advantages that can add additional value to its overall costs. The crucial issue, however, is the affordable housing that would be able to achieve such benefits based on the existing energy and construction market. According to Smith (2012), affordable housing units are residences built exclusively for those whose income limits them the ability to purchase or rent out on the open market (Birrell et al., 2012). Another critical issue is to what extent sustainability features could apply to the construction market based on its existing technical ability.

2.4 Vernacular architecture: Informing contemporary sustainable design for Baghdad

This section presents the historical, natural and cultural background of Baghdad and how architecture design has responded to twentieth-first-century conditions and social values, providing the context for this research. It discusses Baghdad's changing built environments focusing on the Baghdadi vernacular house. It illustrates how vernacular courtyard houses were used in the past and how they have changed and developed over time; it also shows the types of buildings with which they have been replaced. It will also discuss how vernacular and contemporary houses have been built taking the residents needs into account. Resident needs will be discussed in terms of environmental, economic, social and cultural factors. It will also aim to focus on the requirements and architectural factors of the houses, as relevant to the scope of this study.

It should be noted that much of the available literature is quite old. As such, they may present outdated understanding of performance, especially considering the changes in the climate and in particular the social culture of the country (Iraq).

2.4.1. Baghdad: A brief urban history

The round city of Baghdad was developed and expanded through history and the circular shape gradually transformed by many forces such as population growth, the decline of Abbasid Empire, and frequent demolitions and reconstructions (Agha, 2019; Elsheshtawy, 2004). Despite all the expansions and growth of the city (Fig.2.12), the city vernacular form was still the dominant until the late 1920s, when the international style began to emerge (Khodaer & Nassir, 2010).

During the period of 762 to 766 AD, the city of Baghdad was constructed. The city had symmetrical streets, which were enclosed by housing areas and walls circularly and concentrically. As with other early Islamic cities, Baghdad was divided into quarters by the caliph, and a chief was assigned to be in charge of each quarter (Warren and Fethi,1982). The fabric was compact which, in such city, comes as a response to the harsh environment (Al-Kaissi, 1984); where the city appears as a coherent mass of small parcels that shade each other to reduce solar radiation impact (Al-Kaissi, 1984).

The center was preserved for the religious and secular authority, with the Mosque and caliph's and princes' palaces in the center; while the market place was in the city's

periphery (Al-Khafaji & Al-Qaisi, 2012). The location of the mosque in Islamic cities presents its significance; it emphasized the importance of religion in social life. This is also emphasized in the skyline of the city, as the Minarat of the mosque was the highest element (Agha, 2019).

The buildings in that fabric were characterized by formal unity. Except mosques, the palace, and the citadel, all other buildings were of the same height. Alongside ths cultural driver for this urban form, it also helped residents to avoid extra exposure to the sun and dusty wind (Al-Kaissi, 1984). Human scale is also a significant trait of the traditional Islamic city, as it is a way to strengthen the relationship between people and their environment and avoid any sense of alienation (Al-Kaissi, 1984). That trait was also represented by the hierarchical street network which linked the center with the periphery of the city (Al-azzawi, 1984).

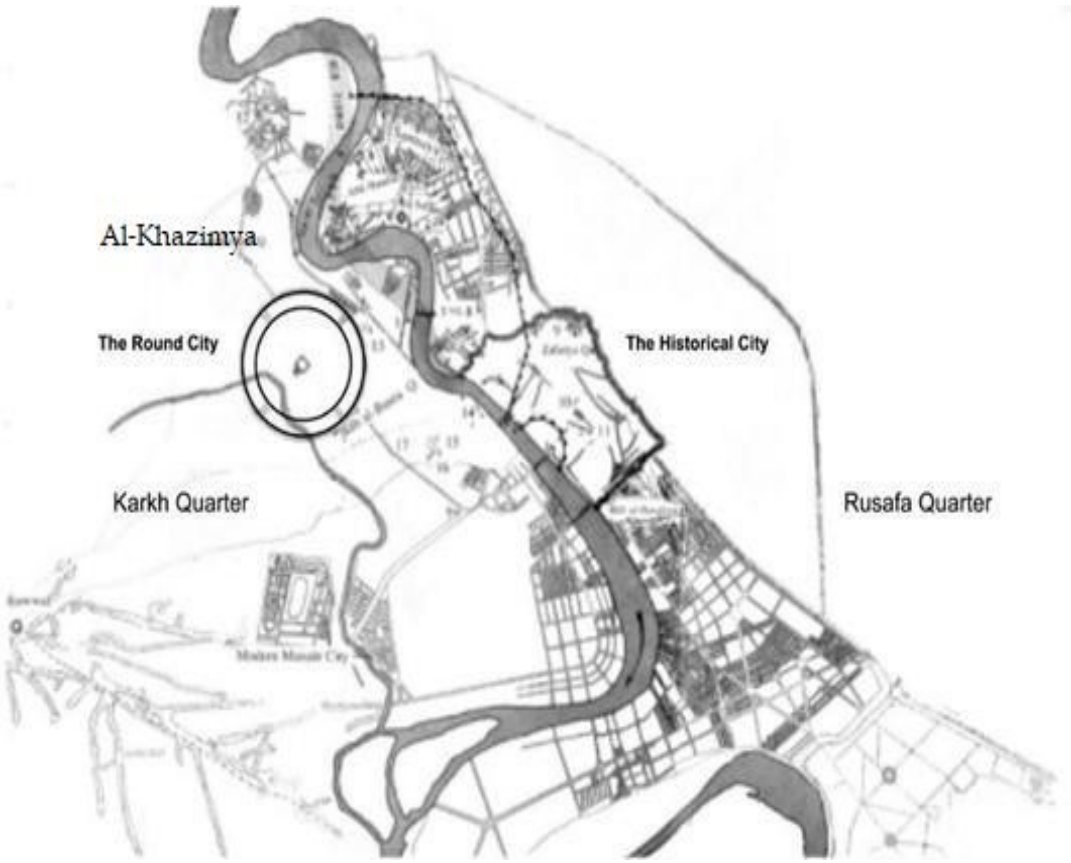


Figure 2.12: *Baghdad round location*

Source: *Elsheshtawy, 2004*

The network ranged from wide streets linked to the center to narrow alleys between the buildings and leading to cul-de-sac paths. Due to the winding nature of the alleyways, air

movement was reduced resulting in the settlement of dust. The height of buildings related to the narrow alleys' width, created shaded and non-shaded areas within each alley and consequently created air movement that mitigated the weather especially in summer. The ratio of street width to building height was 1:2, and sometimes 1:3 or 1:4 (Al-Kaissi, 1984). The minimum width was determined by the space required by "a man riding a fully loaded camel" as a module (Agha, 2019; Mortada, 2003).

With the perishing of the "Round City", Baghdad's medieval core extended downstream further across the river, which was Al-Karkh's opposite bank. This resulted in the walled medieval city where the Al-Rusafa suburb grew. In addition, after ruling the Samara city for 80 years, the Caliph returned here. Later, in AD 1258, the Mongols sacked the Al-Russafa area. However, this was walled again after being re-built. Hence, today the modern Baghdad city's core was survived through the Ottoman period (Warren & Fethi 1982; Al-Kaisi, 1984). Al-Khazimya neighborhood is one of the examples of neighborhoods of this old city.

2.4.2. Baghdad's Current Climate

The various regions in Iraq include desert plateau, mountains in the northeast, highlands, and an alluvial plain; it, therefore, has different environmental conditions. The country's climate is increasingly variable and this has a clear relation to house design and lifestyle, as it is the main challenge to adapting to, and controlling, the changing weather. The climate in Iraq is described as majority desert. There are two main weather periods that take place yearly; December to February is the cold and rainy season and April-end to October-end is the hot and dry season.

Baghdad's climate is described as an arid desert environment, that has extremely heated-dry and shining sun spells (Koppen climate classification, ND). The summer months are scorching and there is low relative humidity with no rain. The air temperature during the summer (between June and August) reaches to a maximum between 44°C to 50°C in the shade and even at night, temperatures in the summer are rarely below 30°C.

. In winter, the minimum daily temperatures can fall below 2 °C while the maximum temperatures typically remain below 18 °C. From November to March, the rainfall averages to up to 1 inch per month, very little rainfall (Weather Station, Baghdad airport 2018). This is illustrated in the data from Table (2.7) and Fig. (2.13). Baghdad still

experiences limited rainfall which does not happen often and when it does it is very minimal; this also goes for the majority of Middle Eastern countries. The breeze also gusts from all directions, however the prevailing and more favoured breeze blows from the south-west (as suggested by Climate Consultant Version 6.0, https://climate-consultant.informer.com/6.0/). The basic climatic elements are explained below.

The summers are very hot but there is a rainy season in the fall. There is no spring season and average temperatures range from 120 ˚F in July and August. The winters are chilly, and temperatures fall to below freezing levels in January. The rainy seasons starts from December and end in April. Most of the rain falls from November and extends till April. Weather remains dry from June to August and these are the hottest months in summer as there is no rain and a clear sky appears due to no clouds (Weather station, Baghdad airport 2018).

Table 2.7: *Climate data for Baghdad*

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
Record high °C (°F)	24.8 (76.6)	27.1 (80.8)	30.9 (87.6)	38.6 (101.5)	43.5 (110.3)	48.8 (119.8)	51.1 (124)	49.9 (121.8)	47.7 (117.9)	40.2 (104.4)	35.6 (96.1)	25.3 (77.5)	**51.1 (124)**
Average high °C (°F)	15.5 (59.9)	18.5 (65.3)	23.6 (74.5)	29.9 (85.8)	36.5 (97.7)	41.3 (106.3)	44.0 (111.2)	43.5 (110.3)	40.2 (104.4)	33.4 (92.1)	23.7 (74.7)	17.2 (63)	**30.6 (87.1)**
Daily mean °C (°F)	9.7 (49.5)	12.0 (53.6)	16.6 (61.9)	22.6 (72.7)	28.3 (82.9)	32.3 (90.1)	34.8 (94.6)	34.0 (93.2)	30.5 (86.9)	24.7 (76.5)	16.5 (61.7)	11.2 (52.2)	**22.77 (72.98)**
Average low °C (°F)	3.8 (38.8)	5.5 (41.9)	9.6 (49.3)	15.2 (59.4)	20.1 (68.2)	23.3 (73.9)	25.5 (77.9)	24.5 (76.1)	20.7 (69.3)	15.9 (60.6)	9.2 (48.6)	5.1 (41.2)	**14.9 (58.8)**
Record low °C (°F)	−11.0 (12.2)	−10.0 (14)	−5.5 (22.1)	−0.6 (30.9)	8.3 (46.9)	14.6 (58.3)	22.4 (72.3)	20.6 (69.1)	15.3 (59.5)	6.2 (43.2)	−1.5 (29.3)	−8.7 (16.3)	**−11 (12.2)**
Average rainfall mm	28.2	19.1	22.0	15.6	3.2	0.0	0.0	0.0	0.0	3.3	17.4	22.0	**156.8**
Average rainy days (≥ 0.001 mm)	8	7	8	6	4	0	0	0	0	4	6	7	**50**
Average relative humidity(%)	71	61	53	43	30	21	22	22	26	34	54	71	**42.3**
Mean monthly sunshine hours	192.2	203.3	244.9	255.0	300.7	348.0	347.2	353.4	315.0	272.8	213.0	195.3	**3,240.8**

Source: World Meteorological Organization (UN) and weather data station, Baghdad airport (2018)

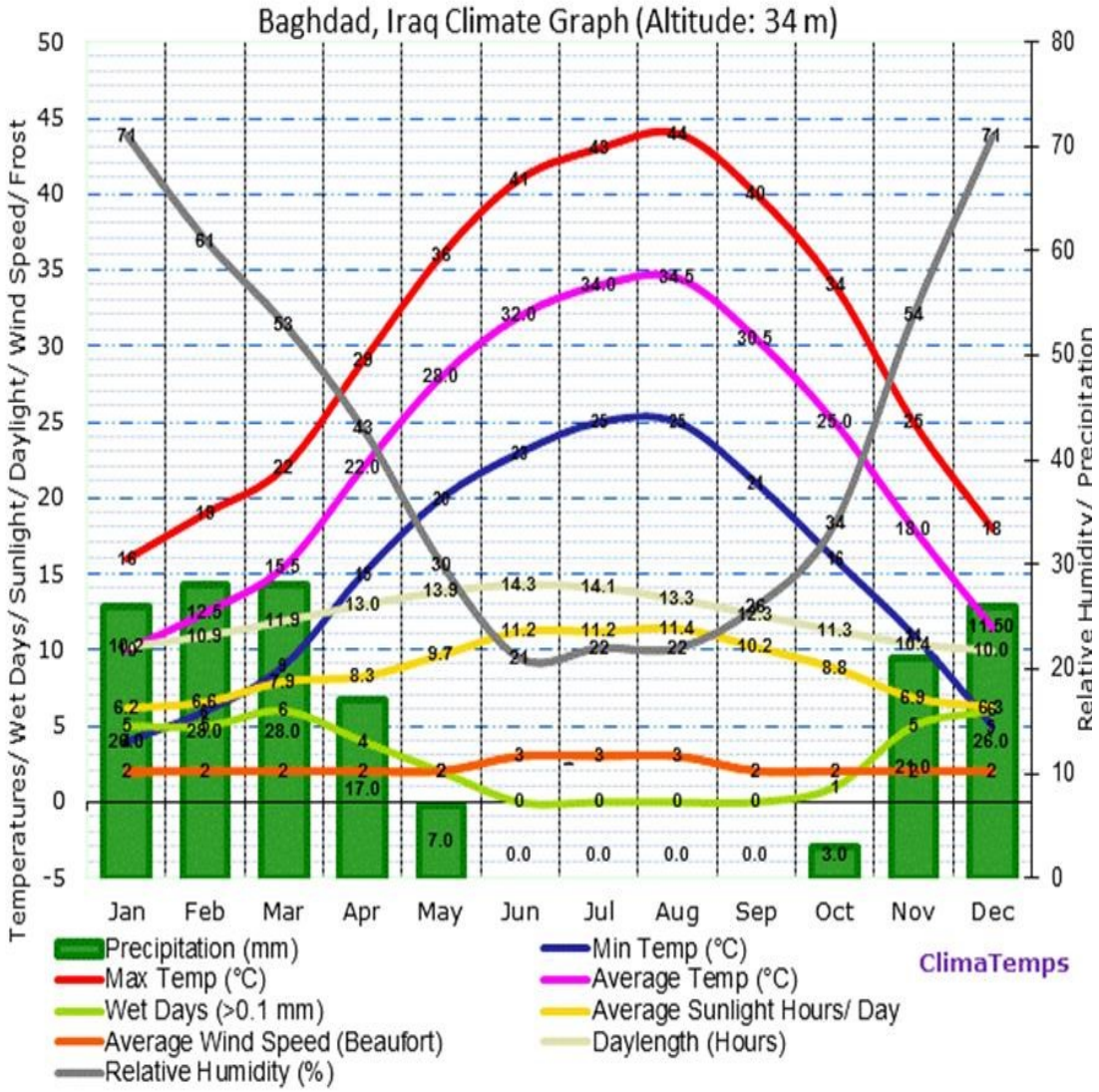


Fig 2.13: Baghdad's yearly climatic change (weather station, Baghdad airport 2018)

- ***Solar radiation and sunshine***

The solar radiation and sunshine are very high in Baghdad. The duration of sun in summer is 14 hours and sunny periods is 12 hours in autumn and spring (Fig. 2.14). In winter, due to clouds, the sun duration varies but mostly 4 hours of sunshine is common (Fig. 2.14). The minimum sun altitude is in winter at noon and maximum in the summer. The monthly average level of solar radiations in the last decade has been 106.1J/cm^2 /day (Hussein, et al., 2013). The internal areas in the buildings are affected by motion of the sun, therefore direct sunlight protection is vital in summer while solar ingress is beneficial in winter.

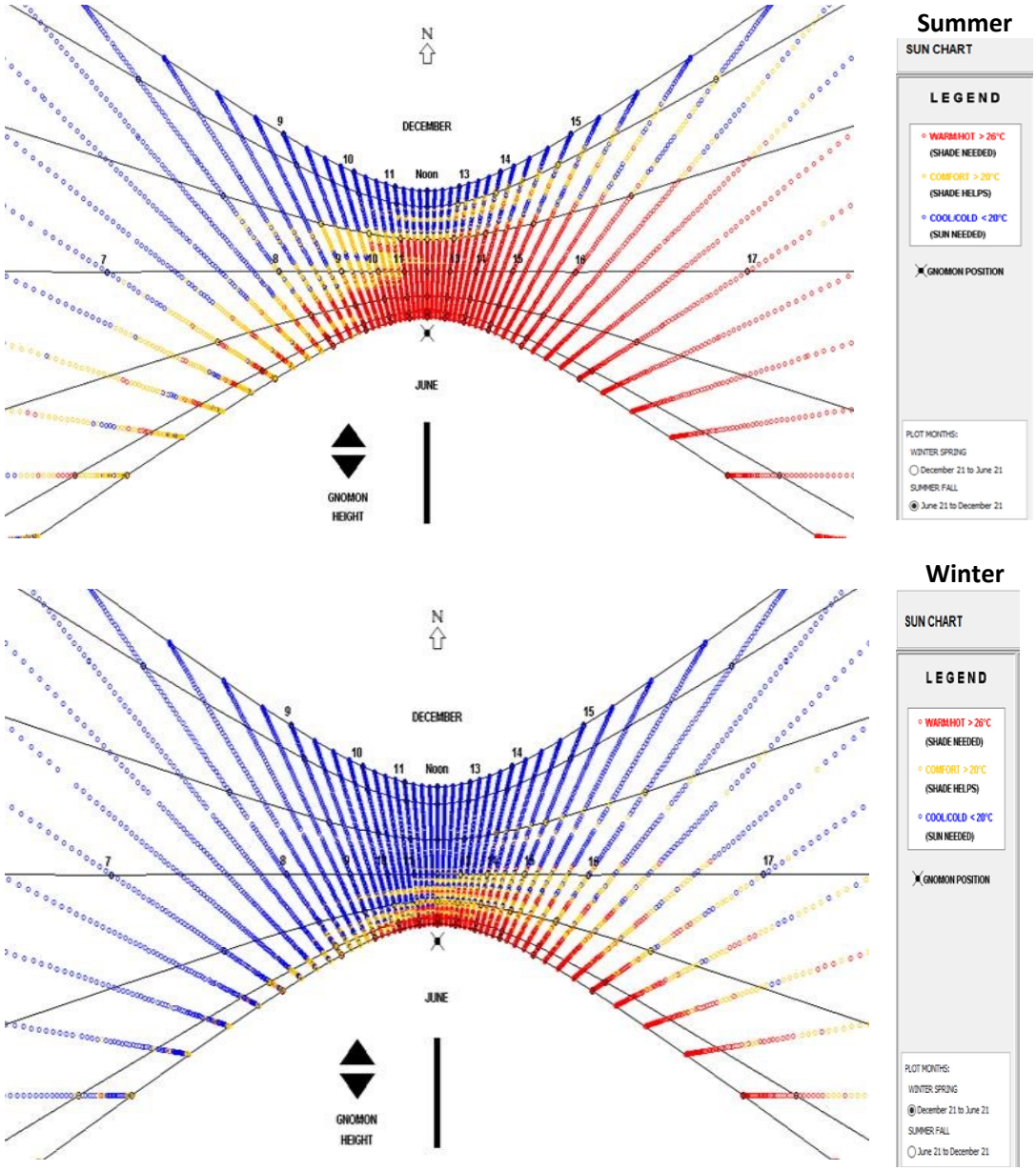


Fig.2.14:*Sun chart(summer and winter)*

- ***Temperature:***

  There are variations in temperature between day and night, summer and winter, and also year to year has a direct effect on the level of comfort in buildings; this requires consideration in terms of how to deal with this element of the climate.

  Summer: Baghdad is one of the hottest cities and it has a climate of a desert, based on the findings of the Koppen Climatic Classification. The temperatures between June and August vary from 44°C to 50°C even at night, the temperature rarely drops below 24°C (Koppen Climatic Classification, ND). In 2018, the temperature reached up to 51°C, which is a record set (Weather Station, Baghdad airport 2018). Furthermore, the

humidity is only 10% in summer as Baghdad is far from the coast of Gulf and southern marshes of Iraq, (Fig.2.15). However, the intense daytime heat during the summer times could be mitigated to an extent in terms of thermal comfort by this low relative humidity (Weather Station\Baghdad, 2019).

Winter: While some chilly nights are present in the winters, the overall winter is known to be mild in the city, mainly during December to February with maximum daily temperatures being in the range of 15.5°C-18.5°C. Mornings are usually chilly, where average temperatures in January can extend to 3.8°C (Koppen Climatic Classification). Overall, the ranges of average temperatures in the country involves originating from temperatures more than 45°C to below freezing temperatures, from July to January, respectively.

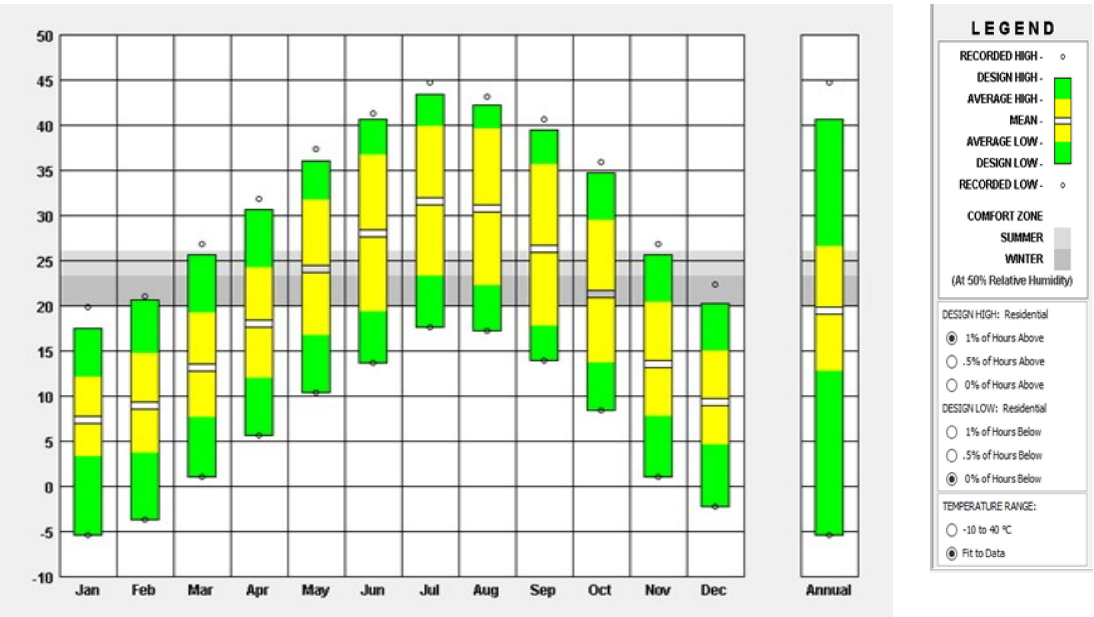


Figure 2.15: *Annual temperature range in Baghdad*

- ***Wind speed and direction***

Baghdad has two kinds of wind pattern. The first involves stable winds from northwest and north which prevail from mid-June to mid-September. An intensive sun heating of the surface of the land is permitted by the dry air which originates from the north. This also offers certain cooling impacts. These dry winds may be accompanied with dust storms, which originate from the southeast and southern regions (Weather Station, Baghdad Airport 2018), Fig (2.17). The second are 80 km/hr., dusty winds, which occur from April to early June. These are then repeated again from late September to November (Weather Station, Baghdad Airport 2018).

Increased wind speeds are sought for in hotter and dryer climates, as expected. In fact, wind has a key role in the thermal comfort of indoor environments as well as on the degree of comfort in the buildings, when achieving maximum benefits from its natural cooling capability.

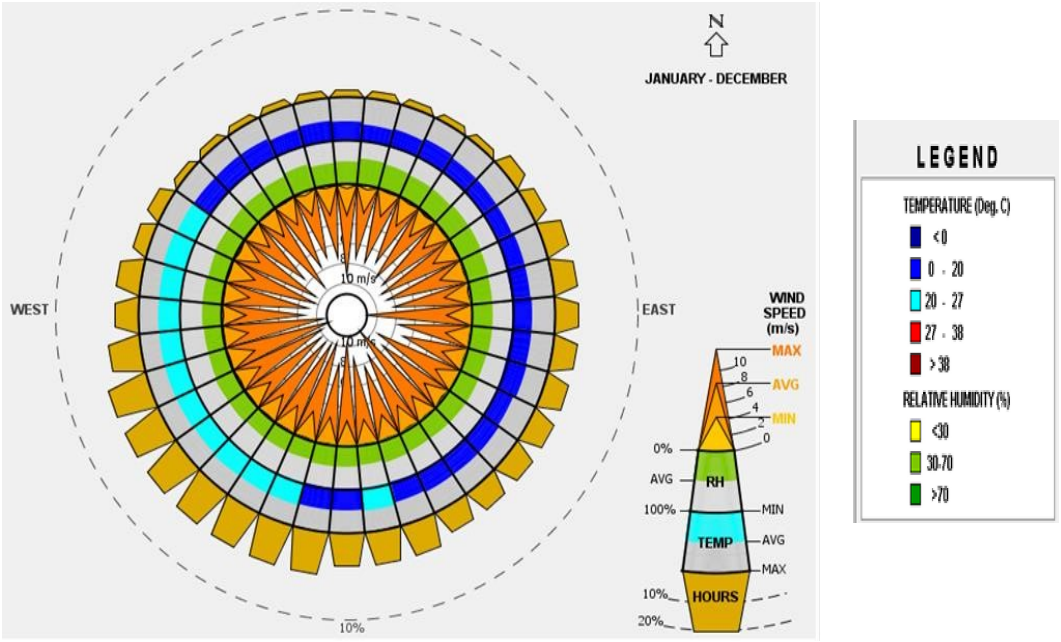


Figure 2.17: Wind velocity throughout the year (weather tool: Climate Consultant)

Table 2.8 gives the average weather condition details over the year in Baghdad, based on the Köppen Climate Classification.

Table 2.8: *The average weather condition details over the year in Baghdad*

Temperature	Average (annual)	22.2 °C
	Range of average monthly	24.5°C
	Average max (July)	50°C
	Average min (January)	-3.9°C
Rainfall	Average annual	154.9 mm
	Average monthly	13.3 mm
	Days with >0.1 mm rainfall	34 days
	Driest months – Avg. 0.0 mm	June, July, August, and September
	Wettest months	January\27.9 mm
Relative Humidity	Average	42.3%
	Average range – daily	17.1% to 71.7%
Sunshine	Annual sunshine hours	3,244 hours
	Average daily hours	8.9 hours
	Min daily hours – January	6.2 hours
	Max daily hours – June	11.6 hours

Source: *Researcher depend on Köppen Climate Classification*

2.4.3. Vernacular houses – background and context

In the mid-18th century, the earliest vernacular houses identified in Baghdad. Inside the Al-Kadhimiya area, the oldest dwellings were found, and the latest houses entirely built in the vernacular style back nearly 175 years (Agha, 2019).

The typical vernacular dwelling type in Baghdad is believed to be the one- or two-story house centered upon one or two central courtyards (Agha, 2019; Warren and Fethi, 1982; Al-Kaissi, 1984; Al-azzawi, 1984). According to Al-Kaissi (1984), vernacular houses of Baghdad have almost exclusively been courtyard houses (Ayyash, 2015). The single-central-courtyard house, according to Al-azzawi (1984), and Al-Kaissi (1984), is the commonest type throughout the cities of central Iraq (Figure 2.19).

The typical vernacular dwelling always faces inwards, so that the plain walls are facing the streets and outside, responding to the desire for privacy and climatic requirements (Warren and Fethi, 1982; Al-Kaissi, 1984; Al-azzawi, 1984).



Figure 2.19: *Central-courtyard houses in Baghdad*

Source: Google Earth (2020)

The literature review (Warren,1982; Warren, 1984; Fethi,1982; Al-Azzawi,1984; Al-Kaisi,1984; and Agha, 2019) states that the vernacular courtyard houses in Baghdad were responsive into climate and the climate has had the strong influence on designing the

homes. Table 2.9 summaries how the vernacular house in Baghdad responses to the environment by created passive systems.

Table 2.9 summaries how the vernacular house in Baghdad responses to the environment by created passive systems.

Table 2.9: *Summary of how the vernacular house responds to the environment with passive systems, (Researcher)*

Site	House	Passive systems	indicators
The urban fabric because of compactness.	Form of the vernacular orientation of the house and space. The presence of architectural elements linked to proportion. Structural linked to the thick walls. Using natural materials. Spaces dimension and relation. Details such as shape and size.	Natural heating	Changing temperatures slowly
		Natural cooling	Cold air then decreases the temperature
		Natural ventilation	Creating air flow and after air movement
		Natural lighting	Lighting the house in the daytime

Table 2.10 and Figure 2.20 show the affective factors on the courtyard performance.

Table 2.10: *The affective factors on the courtyard house performance (Researcher)*

Houses' elements or features	The effective factors	The direct impact
The courtyard	Location Geometrical Characteristics (Height, length and width)	Heat gain and natural ventilation Shading and evaporative cooling
The internal spaces	Openings size and location	Natural ventilation
	The internal dimensions (width, length and height)	
	Seasonal usage of spaces	In summers, the first floor remains unused for a great period of time. This allows for such an area to become a shelter from the solar gains for lower floors.
The wind – tower (Badgir)	Orientation and geometrical properties	Natural ventilation
The Shansheel	Openings size and location	Use of a shaded opening to provide natural ventilation for air passage
The building envelope	Envelop thermal mass (construction materials U-value)	Heat gain
The water& planting features	The ratio of these features area to the courtyard area	Natural ventilation + Heat gain + Evaporative cooling
The building form	Building volume to external surfaces area	Heat gain+ Shading

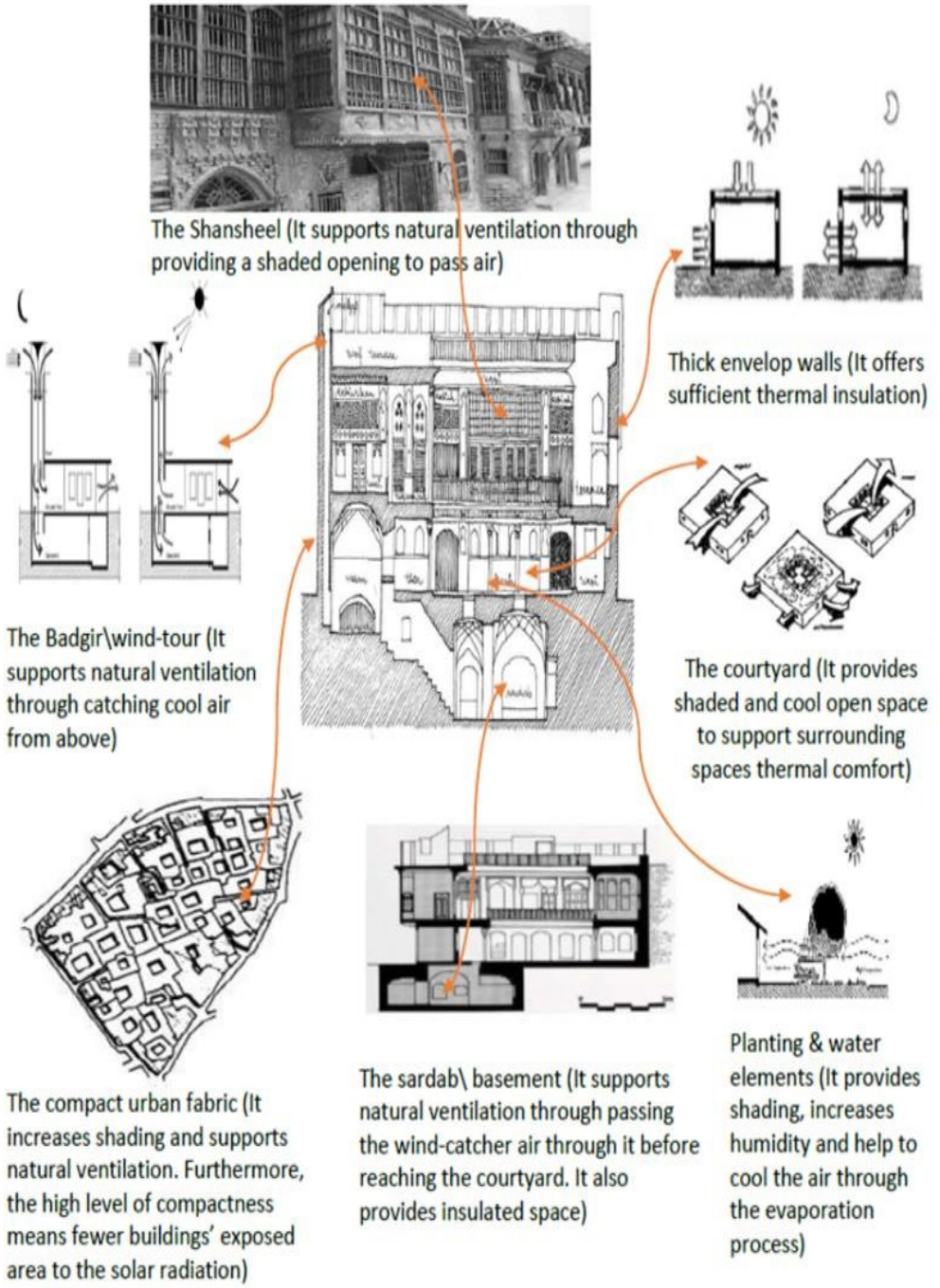


Figure 2.20: *The affective factors on the courtyard house performance*
Source: *Researcher depends on Warren& Fethi, 1982; Warren, 1984; Fethi,1982; Al-Azzawi,1984; and Al-Kaisi ,1984*

Table 2.11 shows the main spatial elements of the vernacular houses in Baghdad, as a case study.

Table 2.11: *The main spatial elements of vernacular house in Baghdad*

Main Spaces and Architectural Vocabularies		Terms (in Arabic)	Descriptions and Functions
Internal space	Entrance passageway and the entry courtyard	Mejaz	It is a circulation space connecting the entry hall with the main courtyard. It is a mediator between inside the house and the outside world. The courtyard acts as an entrance open-space with a staircase leads to upper floors.
	Reception room (for male visitors)	Diwaniya	It is used for male visitors, suited off the entry courtyard.
	A large room of the house closed by screens or windows and entered from the sides	Ursi	It is a specific version of '*talar*'.
	Gallery carried with columns all around a courtyard	Peristyle	It is an extended space in front of the courtyard, and a transitional area from the outside to the inside.
	A room with a raised floor and a side open to the courtyard	Takhtaboush	It is a covered outdoor sitting area, located between two courtyards: one is unshaded and large –paved courtyard, and the other is planted. The main function is to ensure a steady flow of air.
	Low mezzanine rooms	kabishkan	- It is located on the mezzanine of the first floor (above corner rooms "ursi" and "talar"). - Used by women if the main first floor was used for a male reception. - Used by women to ensure their privacy. - It had strategically located windows through which the women could look into the "ursi" or the "tarma" and watch the lower courtyard level across the open colonnade. - Densely screened windows (timber lattice screens – "Shanasheel" to achieve privacy, to project into the street, and to form protected bay windows with integrated benches, which allows for glimpses from the outside world. - The principle of "shanasheel" depends on keeping water jars of unburned clay close to the screen, to benefit from the natural cooling effect of the draft.
	Bed room	-	• Symmetric layouts were applied, but not extended to the central courtyard. • There is a lower (sunken) circulation space (as an entrance) for every room.
	Basement	Sirdab	• It is a single shaft-ventilated subterranean room. • Rooms around the courtyard called "neem", are dropped down by one meter and have a high window (Ragette 2003). • Used in cold and wet northern climates, since it provides a space of even temperature, hardly freezing in winter and never too hot in summer. • It also keeps the ground floor slab warm and dry. • It collects the fresh morning air and preserves it for the hot afternoon hours (Ragette 2003).
External spaces	Courtyard	Hosh	It is an open space (a window to the sky) for performing the functions of daily living while ensuring visual and spatial privacy.
	Portico (Gallery or Balcony) overlooking the courtyard	Tarma	• With a back wall, this is a horizontal linear structure. In addition, the frontal roof edge is supported by a row of columns. • It offers important protection from harsh weather conditions, and a circulation space connecting a series of rooms. • It is usually attached to the courtyard.
	A single open space in front of the courtyard with a pair of columns in front of it	Iwan -Talar	• It is an extended space in front of the courtyard, and a transitional area from the outside to the inside. • Open iwan could serve as a family sitting area or an open-air reception space, with a back wall, affording access and creating a sheltered space. • The open iwan was usually oriented northwards to avoid direct sun radiation, and to catch the cool breeze during hot summer days.
	Roof terraces		• Enclosed by 2 meters high brick walls • Made up for the lack of an open courtyard • It could be used by the women for all domestic activities and Also for sleeping.
Envelope design	Exterior walls		The exterior walls of the vernacular house are constructed using traditional and local materials suited to climatic conditions (such as mud bricks or stone with thickness between 50 cm and 75 cm). These construction materials and the thickness of the walls increase heat storage and delay heat transfer at night.

Source: *Researcher depends on Warren& Fethi, 1982; Warren, 1984; Fethi,1982; Al-Azzawi,1984; Al-Kaisi ,1984; and Agha,2019*

As summarized in Table 2.9 to 2.11 and Figure 2.2, the vernacular architecture had many elements that responded to the weather and climate condition, such as the courtyard that provided light and ventilation and was the temperature regulator and circulation space, as well as the zone where the several stratifications of the house came together. In summary, the courtyard's influence on moderating temperatures and in enhancing air circulation cannot be ignored to ensure adequate ventilation in kitchens, bathrooms and halls. Ventilation can also be organized to work automatically, either daily or seasonally, while solar energy can be harnessed to provide convective drafts either to extract air or bring in temperate air (Stead, 1980, p.43) and (Dilia et al., 2010, p.921). In the courtyard, a concentration of cooler air is kept, as it weighs more than the adjoining warm air and the planted section gives movement and creates a better microclimate in the courtyard and the house through increasing the humidity (Agha, 2019; Oktay, 2002, p.1006).

The composition, design and orientation of bagdire (wind tower) which introduces air from the roof level into the underground level ensure that the external hot and dry air is cooled and humidified. It also helps to induce cross-ventilation in this level, which plays a part in decreasing the temperature of its floor, ceiling, and walls. These surfaces help to keep the internal thermal environment conditions desirable most of the day (Al-Zbaidi, 2002). Al-Temeemi (1995, p.43) found that the bagdire helps to reduce the heat and dry air of the prevailing wind which is cooled by the thermal processes of conduction, convection, and evaporative cooling (Agha, 2019). Therefore, it continues to descend into the vertical air-duct because of the strong winds and also because it has become denser as a result of being relatively cool; by descending in this way, it continues to cool. During the last ten years, El-Shorbagy (2010B, p.17) noted that the internal surfaces of the vertical air-duct have the effect of humidifying and cooling the incoming hot and dry air through the process of evaporative cooling. It does not receive any sunlight, and are therefore always in the shade. They are usually at a lower temperature than that of the incoming external air, particularly where the badgir is incorporated within the thickness of a party wall.

Different authors such as Warren and Ihsan Fethi (1982), and Al-kaisi (1984) have confirmed that the shanasheel served several functions, as follows: To provide adequate cross-ventilation and air-movement. Moreover, they allow the sun to penetrate the

interior in winter in order to make it warmer. There is provision for more shade in summertime from sun on the external and internal elevations by the horizontal and vertical projection, as confirmed by Agha (2019), from the first floor shanasheel past the outside face of the external walls on ground floor. This protects beyond the face of the external wall overlooking the alleyway from harsh weather (Figure 2.21).

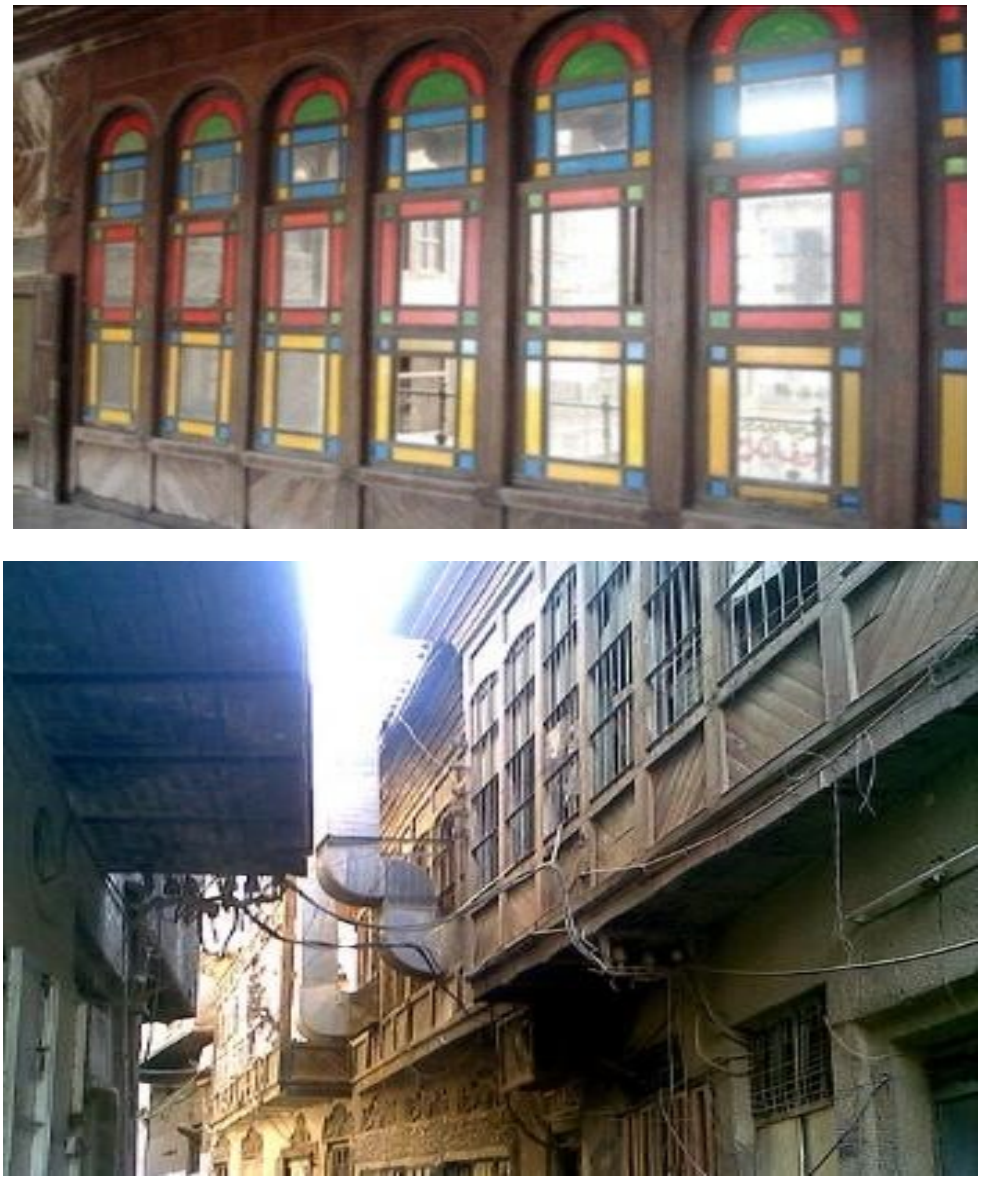


Figure2.21: *The shanasheel is an environmentally, culturally and aesthetically responsive feature that is characteristic to the Bagdad historical. (Researcher).*

The vernacular house was built with thick walls that responded effectively to different environmental conditions. Yang (2007, p.191) clarified that thick walls help to delay and decrease heat gain from the heated outside to the colder inside and therefore retain a comparatively cooler interior in the daytime in summer. Thick brick walls with their high heat holding capacities also have overall high thermal resistances and cause a considerable delay between the maximum external and internal surface temperatures. In 2007 (p.31), Pyla argued that the thick wall gives good thermal insulation in winter and summer.

Furthermore, vernacular house had the ability to reduce heat gain and loss by using natural material (Agha, 2019). Al-Azaawi (1984) pointed out that the use of brick or a mix of clay or chopped dried grasses for the walls and roof provides adequate time-lag to delay and decrease collecting heat from the outdoors to the cooler indoors during the sunny season. This construction also helps to reduce losing heat from the inside to the outside in winter (Al-Azaawi, 1984). Agha (2019) illustrated that the brick used on exterior walls usually has a fine texture and a light colour. This reflects most of the solar radiation; hence, the overall heat gain of the structure is reduced to a great extent. Ozay (2005, pp.845-846) and Hinrichs (1987) added that the heat created by the sun patches formed in the courtyard is either absorbed by the ground or causes evaporation through the bricks which are always wet either from the earth underneath. This helps to increases the comparative moisture of the dry air and lowers its increased temperature. By being exposed to the outdoors, the courtyard floor loses heat by long-wave, outgoing radiation. This radiative heat loss plays a role in decreasing the climate of the courtyard ground and consequently the layer of air it is in contact with; it reduces the temperature of the neighboring lived in rooms and spaces to enhance the thermal comfort, (Figure 2.22).

Moreover, many details in vernacular house were also, response to the environment, for example the massive ceiling structure and construction of its shallow domes, there are arches and vaults which are built of brickwork in Basement. These therefore provide additional thermal insulation against heat gain in summer, to use the thermal inertia of the adjacent floor, and deep walls in providing relatively comfortable internal thermal environmental conditions (Al-Azaawi, 1984 pp.76-77). The parapet wall that included

opining allows cross-ventilation and air-movement to take place through it. These projects have the advantage of losing their heat to the atmosphere by radiation and convection immediately after sunset (Sozen and Gedik, 2007, p.1812). The pathway partially protects the habitable rooms and spaces on the ground floor from harsh weather (Agha, 2019; Moradi and Akhtarkavan, 2008, p.25). Incidentally, Dilia et al. (2010, 2011) highlighted the location of windows at high level also helps to avoid glare from the external ground. In relation to the house, the lesser exposure of the outside walls means the better it is able to fight the scorching heat. Also, it helps to reduce thermal gain to the interior in summer. Agha (2019) stated that the ratio of the void to solid over of the walls in courtyard elevation is very small for lived in rooms used in the hotter season to reduce to the minimum the amount of thermal gain both from the sun and from the hot and dry external surroundings. At the same time, this ratio is relatively large for habitable rooms used in the cold season to encourage thermal gain from the sun; this heat gain helps to warm the interior.

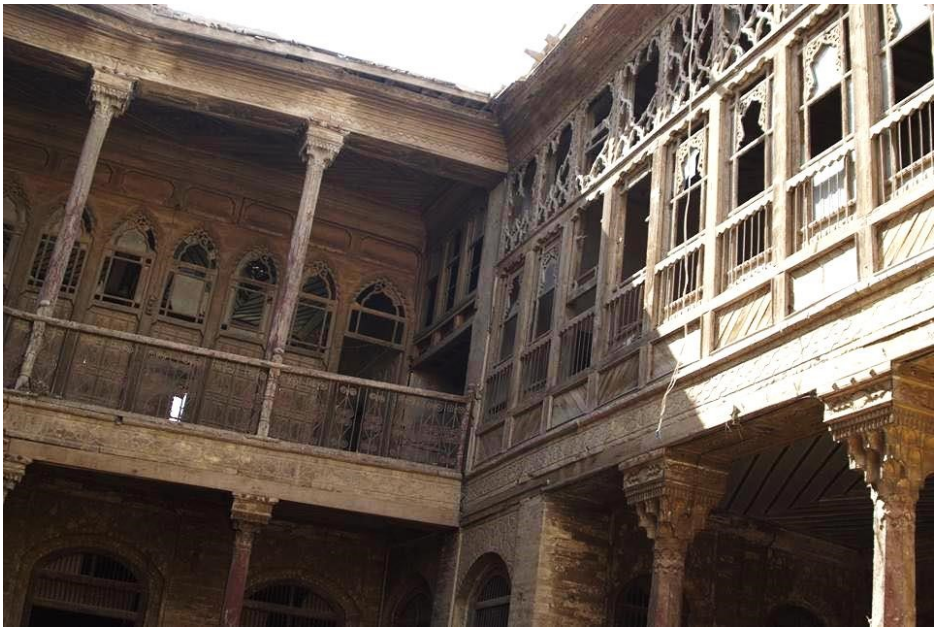


Figure 2.22: *Using natural materials in Vernacular house, Baghdad. (Researcher).*

However, the principle and strategies applied within vernacular house arguable combine to achieve appropriate environmental performance; providing thermal comfort especially

in the summer. This was achieved by the specific components in the vernacular; embedded passive systems which sought to respond to a number of environmental factors. The research reviewed here determined these factors according to their impact on thermal comfort related to cooling, heating, and ventilation, as well as lighting. As a result, desirable environmental conditions were experienced by the inhabitants at various times during different seasons in the various areas and spaces of the vernacular house.

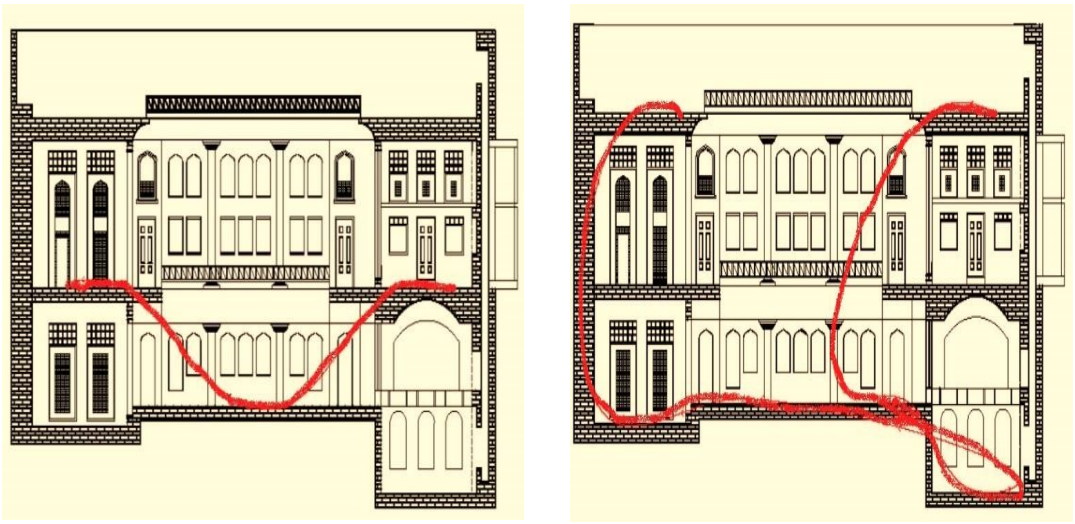
As a result, the many strategies employed in the vernacular house relied upon occupants' movements; a flow of the arrangements of the family across the day/ season can vary, corresponding to micro climate conditions provided by the vernacular courtyard houses. These related to the influence of the movement of sun and wind, changes in temperature which differentiate and typify one main season from another, and also one transitional season from another. Stead (1980, p.43) pointed out in the vernacular house that there is a noticeable migration from the cool cellar at daytime to the cooler roof at night. The important point to note is why this happens and to and give enough time to gather the results. We can classify this movement in Baghdad especially as follows:

Seasonal occupants' movements: In the case of Baghdad, its residents had to change their family living activities biannually. According to Al-Azzawi (1996B), who classified the seasonal occupants' movements into two movements:

Firstly, Movement during the **cold season:** The ground floor is used now and again at day; however, it is not entirely left alone as the core household duties are still conducted there. The first-floor use is for varied other family type events. Therefore, the ground floor is not used as much as the first-floor; this is due mainly to rising dampness at ground floor and the basement. With this change, the occupants forgo the outdoor secluded open spaces and in-between spaces on the ground floor for the enclosed and closed inside spaces on the first floor. Also, the first floor obtains sunlight for a longer time than the ground floor.

Secondly, Movement during the **hot season:** Due to the more comfortable micro-climatic conditions, the residents utilise the ground floor, the roof and the underground level. With this change, the occupants forgo the inside closed spaces on the first floor for the outside secluded open spaces. It is worth noting that, all year, the ground floor receives

less sunlight than the first floor and thus from a micro-climatic viewpoint the ground floor is more appropriate and attractive for summer inhabitation than the first floor, because of the scorching and dry micro-climatic conditions predominating in it. Figure 2.23 illustrates these different movements in different seasons, to accomplish daily activities.



Winter **Summer**

A.) The families focused on the first floor of their activates and the ground floor is not used as much as the first floor.

B.) The families focused on the ground and sardab floors of their activates and the roof and the first and second floors were not.

Figure 2.23: *The horizontal as well as vertical movements in sections of the house in different seasons, to accomplish daily activities of vernacular house in Baghdad, (Researcher)*

Daily occupant movement: In one day, an urban family might have a different routine in the summer compared to the winter. This is due to the climate change outside and therefore families change their lifestyle to adapt. For this same reason, the design of the whole construction of the buildings need also to take this into account. Al-Azzawi (1996A) identified two types of daily shifts in the vernacular house in Baghdad.

Vertical movements in summertime: Vertical movements occur in section, and happen between one level and another generally by going through the courtyard. During a typical day in the hot and dry season, the family spend the night asleep on the roof on the second floor, and in the morning go to the ground floor and usually eat breakfast in the courtyard

or a space near it. The residents move from side to side or from corner to corner in the courtyard at mid-morning where they have lunch. Following lunch, the occupants generally go down to the inhabitable rooms on the ground floor or underground levels. They forgo their shelter underground and begin living above ground on that day at around tea time. Around sunset, they will return to the terrace. The courtyard is where dinner is served, or the half-open area on the ground floor. After that, the residents go up to the roof level where they have their daily evening.

Horizontal movements in summertime: Horizontal movements are performed by plan and occur either within the courtyard or between one space and another. These movements happen in different time periods. Firstly, at mid- or late morning to escape the direct sunlight, the inhabitants move sides in the courtyard by following the comparative coolness of the shade. Secondly, around midday, when the sun is at its zenith, the occupants go into a space on the ground floor leaving the courtyard. Thirdly towards the evening, the people living there move from the semi-open space and again go to the courtyard to benefit from the hot floor to the cooler sky, when the zenith is at its coolest. The physical vertical and horizontal movement between the house parts during the day and night or winter and summer reflects the original family lifestyle in vernacular house in Baghdad.

2.4.3.1. The factors effective in providing comfort in vernacular houses: thermal and socio-culturally factors

Various factors will be reviewed below and as well have been considered across this research chapters as the most significant issues for the inhabitants of that house types.

The following themes will be reviewed within the course of the research:

- Urban design factors.
- Architectural factors.
- Environmental factors.
- Socio-cultural factors.

Urban design factors in vernacular houses: This section examines the literature review results on the extent to which urban fabric of the vernacular houses satisfy the needs of their occupants in an environmentally and social-cultural ways. One urban planning design strategy noted by Agha (2019) is that due to the compact urban layouts of the vernacular houses, the closeness of the houses produces shadings that in the summer give protections from the sun. The house's internal walls are also very thick and they're always in the shade, thus providing comfortable internal thermal environment conditions for the interior. Further details of the urban design strategies associated with vernacular housing, as noted in the literature, are given in Table 2.12.

Table 2.12 Shows the urban design strategies of the vernacular houses.

Table 2.12: The urban design strategies

Design strategy		Description	Ref.
Urban fabric aspects	**Compactness and street layout**	It has been found from the literature that the urban fabric of the vernacular areas is compact and vernacular house residents are content about the neighborhood they reside in. In addition, all workplaces, schools as well as shops are in the homes' walking distance. Also, it was revealed that residents tend to socialize with their neighbors in a frequent manner. With the vernacular areas, using car shows difficulties in accessing homes due to the alleyways which are mostly narrow.	(Fethi,1982; Al-Azzawi,1984; Al-Kaisi,1984; Agha, 2019)
	Orientation	The orientation of vernacular house was formed according to the socio culture effects and as an appropriate response to bioclimatic regions with the experience of centuries. Though we cannot claim that it is only the reason for the formation of dwellings, the both effects of socio culture and bioclimatic regions of Iraq not be neglected. For example, in vernacular house it is considered very valuable to build the main facade towards "qibla", the direction towards the holy land of Islam (Mecca). The optimum orientation for unilateral houses in Baghdad are south and may be 30 west of south. The direction of Mecca from Iraq are almost south, 20 and 10 west south. I t can be easily seen that these directions are either almost exactly optimum direction, or they are in the optimum direction range.	(Warren, 1984; Fethi,1982; Al-Kaisi,1984; Agha, 2019)
	Outside zone	It has been found from literature that courtyards have the potential to provide privacy for the inhabitants when doing most normal day to day activities.	(Al-Kaisi,1984; Agha, 2019)

Architectural factors in vernacular houses: The architectural factors are related to the understanding of the extent to which vernacular houses architecture satisfies the needs of the occupants, like the types and functions of habitable spaces and rooms. Researchers in this field have identified these architectural factors being important. Table 2.13 shows the architectural factors strategies of the vernacular houses that relevant to this thesis. It can be seen that this description and understanding of the vernacular houses occupation depended on an essential understanding of the houses' passive functioning; thoroughly, it provides a comprehensive understanding of climate and seasonal responsive living techniques and strategies.

Table 2.13 : *The architecture design strategies in vernacular house*

Design strategies		
Architecture design aspects	Form	
	Window design	Size of window
		Shading device
	Glazing design	
	Envelope design	
	Roof terrace design	

Researcher depend on (Warren, 1984; Fethi,1982; Al-Kaisi,1984; Agha, 2019)

Form: The form of vernacular house was formed according to the socio culture effects and as an appropriate response to bioclimatic regions with the experience of centuries (Al-Kaisi,1984; Agha, 2019). Though we cannot claim that it is only the reason for the formation of dwellings, the both effects of socio culture and bioclimatic regions of Iraq not be neglected. the literature shows that the introverted courtyard style is still the ideal type, considering their weather conditions and cultural inclusiveness in Baghdad, Iraq (Warren, 1984; Fethi,1982; Al-Kaisi,1984; Agha, 2019). The houses are usually rectangular or cubic in shape and courtyards reduce the exposed area to sun in summer and winter rains. In a typical Baghdadi house, traditionally the vernacular courtyard house observed cultural values through its type, where windows opened in the courtyard instead of facing the neighbourhood, thus facilitating the increased dweller's control over the physical form

above their comfort (Agha, 2019). The courtyard's influence on moderating temperatures and in enhancing air circulation cannot be ignored to ensure adequate ventilation in kitchens, bathrooms and halls (Warren, 1984; Fethi,1982; Al-Kaisi,1984; Agha, 2019). Also, vernacular houses' compact layout along with the nearness in houses allows for protection of these houses from the rain in winter and sun in summer. Modifying the microclimate and maintaining familial privacy, which had been solved in the vernacular house by the form which allowed the openings to be directed to the courtyard is not applied in the contemporary Baghdadi house (Agha, 2019). The secret behind the success and uniqueness of the vernacular form of the Baghdadi house was that it brilliantly solved the equation that contains different environmental and social variables in a very advanced manner.

Window design: The literature review (Warren,1982; Warren, 1984; Fethi,1982; Al-Azzawi,1984; and Al-Kaisi,1984; and Agha, 2019) states that the window (shanasheel) in vernacular house was formed according to the socio culture effects and as an appropriate response to bioclimatic regions with the experience of centuries. Though we cannot claim that it is only the reason for the formation of dwellings, the both effects of socio culture and bioclimatic regions of Iraq not be neglected. Shanasheel was widely used in the facades of the vernacular houses in Baghdad. The shanasheel is an efficient feature in providing privacy, shade and encouraging air circulation by permitting the opening of windows while screening the occupants within. In the modern era such functional and cultural purposiveness has been neglected. Thus, whereas the shanasheel was used both for functional and aesthetic purposes, its effect could be achieved by contemporary architecture, with the same cultural and environmental value.

Windows glazing: It has been found from the literature that the design of shanasheel in vernacular house consists of projecting oriel windows enclosed with lattices found on the second floor of the house or higher, often lined with stained glass. This is a key feature for reducing solar gains and thereby reducing energy consumption. Also, it is to provide natural light at the same time.

Envelope design: It has been found from literature that the function of the house envelope is to resist the heat transference, reflecting the sun rays as possible, minimise the solar and

heat gain in order to create cool conditions inside and counteract the excessive solar gain. The exterior walls of the vernacular house constructed using traditional and local materials suited to climatic conditions like mud brick or stone with thinness between 50 - 75 cm. These construction materials with the thickness increase the thermal insulation in the day time and store as well as delay heat transfer at night.

Roof terrace design: It has been found from the literature that the vernacular house offers complete privacy to inhabitants as an area of sleeping in the night during the summers. The parapet wall and its height allow the prevention of peeking from neighbours.

The Socio-cultural factors in vernacular houses: This section presents literature outcomes on the socio-cultural issues related to vernacular house; in previous studies, privacy has considered a significant aspect of society in Baghdad, however, the extent to which this is remain important in the current context in spite of the changes in the society's fabric is subjected to query.

The vernacular house design evolved to respond through sets of objectives; this housing type was built to fulfil and satisfy the occupants' functional requirements, for instance the environmental and socio-cultural demands. This section focuses on the social-cultural aspects which driven the designs, particularly the strategies to provide full privacy for the occupants (Agha, 2019; Salman, 2017).

The following design strategies will be discussed and illustrated below:

- Entrance (Mejaz);
- Courtyard;
- Rooms inwards looking to the courtyard;
- Shanasheel;
- Spirited Male visitors room to achieve inhabitant's privacy;
- Roof terrace – sleeping.

Plans and images of the vernacular house are provided below, in Figure 2.24 to 2.28, and Table 2.14 provides the details of design strategies.

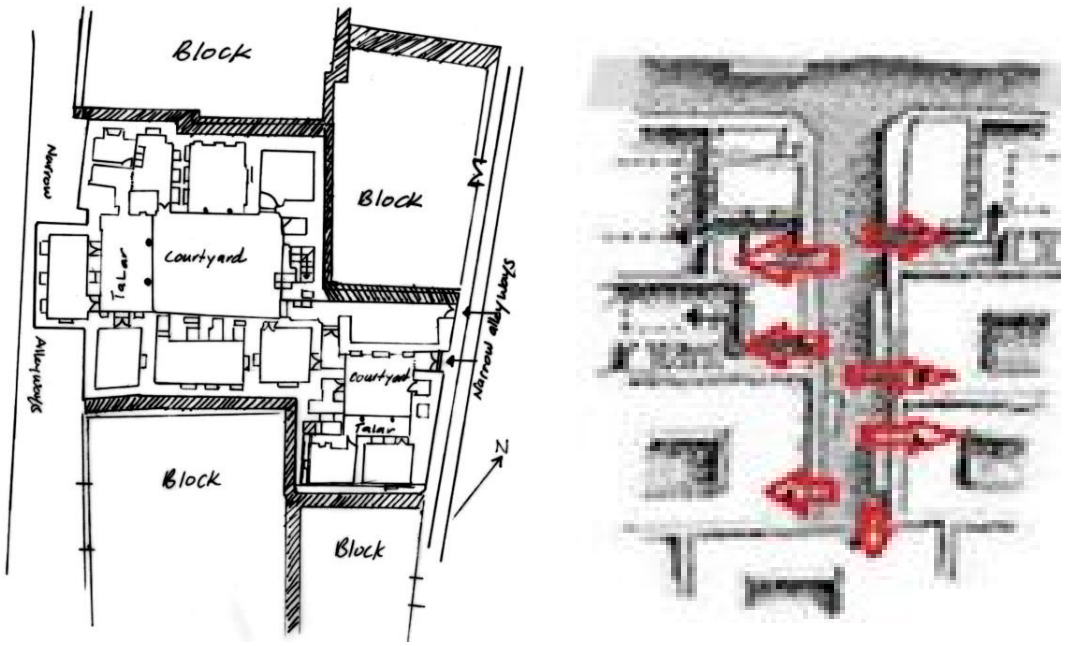


Figure 2.24: *Entrance design in vernacular house (Researcher)*



Figure 2.25:*An exterior view of the entrance in the vernacular house (Researcher)*



Figure 2.26: *An interior view of the entrance in vernacular house (Researcher)*



Figure 2.27:*The interior of the shanasheel room(Researcher)*



Figure 2.28: *The ursi room internal*

Source: *(Salman,2016)*

Table 2.14 shows details of Socio-cultural design strategies.

Table 2.14: *Socio-cultural factors in vernacular house*

Socio-cultural strategies	Descriptions
Entrance (Mejaz)	The architectural design of the entrance prevents the direct eye contact from outside towards the social area of the house, so protecting insiders from outsiders' glances.
Courtyard	• provide privacy for the inhabitants when doing most normal day to day activities • Providing the intermediate connection between the various components and sub-units of the house.
Rooms inwards looking to the courtyard	The core of vernacular homes is considered to be the courtyard where all rooms face towards it. Thus, it has the potential to provide confidentiality for the inhabitants while doing most normal day to day activities.
Shanasheel	the Shanasheel, which assists in maintaining interactions among women from neighbouring houses.
Spirited Male visitors room to achieve inhabitants privacy	The traditional house comprises of reception room (inhabitable room) in order to provide complete privacy. It is used for male visitors, suited off the entry courtyard. The access to this room is through Mejaz, the entrance of the house. The semipublic areas are connected to the semipublic entrance hence allowing views from men, guests and outsiders.
Roof terrace	Provision of overall privacy for sleeping at night-time during summers. The high enough parapet wall makes it helpful to avoid unnecessary glancing from neighbors.

Source: *Researcher depend on (Warren,1982; Warren, 1984; Fethi,1982; Al-Azzawi,1984; Al-Kaisi ,1984; Ragette 2003; and Agha,2019)*

The cultural, social and behavioural rules are considered for different spaces of the house. Vernacular houses have social spaces according to lifestyle of family members in Iraq (Khattab, 2013). It's a known phenomenon that family affiliation, social identity and culture is representative of the homes (Jiboye and Ogunshakin, 2010). Hence, relevant authorities and organizations are usually careful about considering the requirements of the families. This involves developing suitable solutions based on the limited spaces in order to incorporate the varying cultural as well as social requirements. This allows for incorporating degrees of privacy within houses even though the house plans are rigid (Boudiaf, 2010). For instance, with the expectation of an arrival of a new member such as a spouse or a baby in the house, the house immediately requires a crucial change, specifically in terms of its spatial organization. This is to allow the embracement of the new family member. Maintaining the religious as well as social and cultural values is extremely important. This is represented in the functional, spatial and physical characteristics of buildings and construction sites such as talar and iwan, where the plantation and space are divided spatially. The spatial organization and architecture of vernacular houses and their activities tends to play a great role in maintaining family ties with protected sheltering without any involvement of outsiders. The privacy in Iraqi house is maintained through cantilevered components, which are a representation of the physical elements within a housing unit that allow for users' privacy. These are particularly important for women in order to allow them to maintain gender segregation and achieving visual contacts with required visitors and outsiders without getting observed by anyone who is not a member of family. Similarly, one of the cantilevered components is the Shanasheel, which assists in maintaining interactions among women from neighbouring houses. This is due to the design of this kind of architecture, which consists of projecting oriel windows enclosed with lattices. The level and degree of privacy depends upon the residents of different houses as each individual tends to have their own opinions based on their beliefs. Hence, each housing unit has differences in their interactions to the other residents. It is known that over a period of time, there might be some changes in an individual's opinions (Rapoport, 2007). There are several physical boundaries in a typical house. These include domains which allow for public interactions through alleys (often known as agd) and entrance spaces (often referred to as mejaz). This

kind of tradition is seen in most vernacular housing units in Baghdad. One typical example is in AlKadhimiya, where the Al-Kubai house shows a similar trend in the housing pattern (Agha, 2019; Ragette, 2003). The architectural design of the entrance prevents the direct eye contact from outside towards the social area of the house, hence protecting insiders from outsiders' glances. Semi private and private areas in a house are representative of a house's sociocultural core of the house. The semipublic areas are connected to the semipublic entrance hence allowing views from men, guests and outsiders. In addition, wedding events also take place in such areas. In terms of the private and public areas, these are mainly made to attend known outsiders and guests (Madanipour, 2003). The entrance hall is surrounded in an explicitly spatial order. In this way, the permeability and visibility of the residents and their belongings is controlled (Figure2.26).

It has been found from literature that courtyards have the potential to provide privacy for the inhabitants when doing most normal day to day activities. Furthermore, the roof terraces provide the occupants through complete privacy as a sleeping areas in the night during the summer time. This is due to its parapet wall being high sufficient to prevent overlooking by neighbors. The literatures' review indicate that the vernacular dwellings are fashioned in order for satisfying socio-cultural requirements for the people relating to provide the complete privacy in terms of avoiding unnecessary glancing by neighbours, in addition to gender parting (Agha, 2019; Warren,1982; Warren, 1984; Fethi,1982; and Al-Kaisi ,1984).

Environmental factors in vernacular houses: This section presents literature findings on environmental factors related to vernacular houses, which affect the occupants' thermal comforts during the summers and winters times. This section examines the literature review results on the extent to which vernacular houses satisfy the needs of their occupants in an environmentally way.

This section is considered within two parts. First, those techniques and strategies are intended to have an impact on the summer thermal comfort that will be considered, and then those designed for thermal comfort in winter. The environmental architectural

factors donate to the shared architectural characteristics have been developed to respond locally to the prevailing conditions.

The literature review (Warren,1982; Warren, 1984; Fethi,1982; Al-Azzawi,1984; and Al-Kaisi,1984; Agha, 2019) states that the vernacular courtyard houses in Baghdad were responsive into climate and the climate has had the strong influence on designing the homes. Table 2.14 shows the design strategies in vernacular house in Baghdad. Firstly, the passive cooling strategies for thermal comfort in the summer is considered and the passive heating for winter in houses in Baghdad.

Table 2.15: The design strategies in vernacular house in Baghdad

Passive cooling strategies (Summer)	**Passive heating strategies(Winter)**

• Self-shading:
  ○ Urban Design Scale
  ○ Building scale
• Strategies to protect from dust storms
• Earth Shelter: basements to ensure benefits from earth's protection.
• High thermal mass.
• Natural ventilation systems: Badgir (wind-tower) for promoting cooling via ventilation.
	• Solar Gain
	• Protection from the Rain
	  ○ Urban Scale
	  ○ Building Scale
	• Protection from wind.
	  ○ Urban Scale
	  ○ Building Scale

• Using different spaces in different weather that enable function response to climate	

Researcher depend on the literatures review (Warren,1982; Warren, 1984; Fethi,1982; Al-Azzawi,1984; and Al-Kaisi ,1984)

The vernacular house in Baghdad is response to the changing of environmental condition such as the air movement and air flow of wind, the sun light, and also the change in temperature vernacular courtyard houses during the day and seasons to promote the house performance through the following descriptions:

Summer environmental (Overheating Prevention) Strategies in vernacular houses:

This section is considered those techniques and strategies that are intended to influence the summer thermal comfort that will be considered.

As has already shown in the literature, the vernacular houses are occupied in a manner that is responsive to the changing climate with spaces specially designed and used at the extremes of climate, hot and cold times of the year (Salman, 2017; Agha, 2019). In line with this, it could be established in the literature that, for at least 8,000 years, the climate has had a strong influence on vernacular architecture in Iraq (Nooraddin, 2004). As previously mentioned in this chapter, Iraq lies in the hot-dry region, where the relative humidity is very low in the summer, and the winter is cold or mild, moreover where summer daytime temperatures maybe about 50 °C in some areas, as is observed in Iraq.

Table 2.15 shows the Summer environmental strategies in vernacular house in Baghdad.

Table 2.15: *The design strategies in vernacular house in Baghdad*

Summer environmental strategies

• Self-shading:
  o Urban Design Scale
  o Building scale
• Strategies to protect from dust storms
• Earth Shelter: basements to ensure benefits from earth's protection.
• Natural ventilation systems: Badgir (wind-tower) for promoting cooling via ventilation.
• High thermal mass.
• Seasonal use of spaces

Researcher depend on the literatures review (Warren,1982; Warren, 1984; Fethi,1982; Al-Azzawi,1984; and Al-Kaisi ,1984)

Solar Shading\ urban: According to Agha (2019) work concerning cooling by shading in vernacular Iraqi concepts, the vernacular house in Baghdad reflects the need to achieve

thermal comfort. External spaces like the courtyards and roofs as well as the house's compact layout explain the bioclimatic house concept.

As has shown in the literature (Warren,1982; Warren, 1984; Fethi,1982; Al-Kaisi,1984; and Agha, 2019), the compact urban fabric as achieved by Baghdad's vernacular design strategies supported natural ventilation as well as self-shading, increased compactness exposes a lower proportion of building fabric to solar radiation. Moreover, shanasheel was widely used in the facades of the vernacular houses in Baghdad. The shanasheel is an efficient feature in providing privacy, shade and encouraging air circulation by permitting the opening of windows while screening the occupants within.

Solar Shading: Building Scale: The reduction of the surface area open to direct solar radiation during summertime is important as habitable rooms open directly onto the courtyard and the courtyards are visible to the sky. In the book "Housing in Arid Land," Fried and Labs (1980) pointed out that the vernacular house in an arid zone is protected from direct sunlight, speed wind, and different temperature, dust storm through the inward-looking plan.

The full height of the ground floor is often less compared to the peak of the first floor, particularly in the vernacular house, which response to thermal gain and loss in different seasons. The ratio for habitable rooms used for summertime inhabitation and located mainly at ground level is very small in order to reduce, and even avoid, the thermal gain to the interior either from the sun directly or from the hot and dry outdoors.

Dust storms: As the vernacular courtyard houses are exposed to the dust storms of spring/summer, the courtyard isn't protected from dust when used by the occupants for their daily life activities during the daytime (Warren &Fethi,1982; Agha,2019). But sometimes during the dust storm, the courtyard is covered to provide some protection from dust to the occupants (Al-Azaawi, 1984; Agha,2019).

Earth Shelter\ basements: The presence of a basement enables vernacular house to store heat and cold through via natural resources. The design of underground levels is either completely or partially buried in the ground, and so is kept cool throughout the day mainly by the effect of the surrounding ground. Therefore, they receive very little or no

direct sunlight either by their orientation away from the sun or by another space. Hence, the problem of heat gain from direct solar radiation is avoided. Thermal inertia encourages natural coolness and heating in the vernacular courtyard house by using soil energies to achieve relative thermal comfort conditions in summer or winter (Leylian et al., 2010, p.279). As Labs stated (1980, pp.123-125), underground placement is a total shading approach to the elimination of direct solar heat load on surrounding walls. The great virtue of this technique is that it is self-shading to achieve coolness; no adjacent or adjoining structures are necessary to capture its benefits. Al-Mumin (2001, pp.105-106) argued that the main advantage of using underground levels is the comparative seclusion from the outer environment. For the vernacular house, this indicates thermal constancy which leads to thermal comfort.

Natural ventilation: As has already shown in the literature (Warren,1982; Warren, 1984; Fethi,1982; Al-Kaisi,1984; and Agha, 2019), the vernacular houses have a natural ventilation system. The composition, design and orientation of badgie (wind tower) which introduces air from the roof level into the underground level ensure that the external hot and dry air is cooled and humidified. It also helps to induce cross-ventilation in this level, which plays a part in decreasing the temperature of its floor, ceiling, and walls. These surfaces help to keep the internal thermal environment conditions desirable most of the day (Al-Zbaidi, 2002). Al-Temeemi (1995, p.43) found that the badgir helps to reduce the heat and dry air of the prevailing wind which is cooled by the thermal processes of conduction, convection, and evaporative cooling (Agha, 2019). Therefore, it continues to descend into the vertical air-duct because of the strong winds and also because it has become denser as a result of being relatively cool; by descending in this way, it continues to cool. During the last ten years, El-Shorbagy (2010B, p.17) noted that the internal surfaces of the vertical air-duct have the effect of humidifying and cooling the incoming hot and dry air through the process of evaporative cooling. It does not receive any sunlight, and are therefore always in the shade. They are usually at a lower temperature than that of the incoming external air, particularly where the badgir is incorporated within the thickness of a party wall.

Also, the shanasheel provide adequate cross-ventilation and air-movement. As well, the courtyard's influence on moderating temperatures and in enhancing air circulation cannot be ignored to ensure adequate ventilation in rooms. courtyard the middle is the lung and the main the breathing space for the house and who works as an organizer thermal benefiting from the high volatility of temperatures between night and day. In the courtyard, a concentration of cooler air is kept, as it weighs more than the adjoining warm air and the planted section gives movement and creates a better microclimate in the courtyard and the house through increasing the humidity (Agha, 2019; Oktay, 2002, p.1006).

High Thermal Mass: The vernacular built with thick walls that response to different environmental conditions. Yang (2007, p.191) clarified that thick walls help to delay and decrease heat gain from the heated outside to the colder inside and therefore retain a comparatively cooler interior in the daytime in summer. Thick brick walls with their high heat holding capacities also have overall high thermal resistances and cause a considerable delay between the maximum external and internal surface temperatures. In 2007 (p.31), Pyla argued that the thick wall gives good thermal insulation in winter and summer.

Furthermore, vernacular house had the ability to reduce heat gain and loss by using natural material (Agha, 2019). Al-Azaawi (1984) pointed out that the use of brick or a mix of clay or chopped dried grasses for the walls and roof provides adequate time-lag to delay and decrease collecting heat from the outdoors to the cooler indoors during the sunny season. This construction also helps to reduce losing heat from the inside to the outside in winter (Al-Azaawi, 1984). Agha (2019) illustrated that the brick used on exterior walls usually has a fine texture and a light colour. This reflects most of the solar radiation; hence, the overall heat gain of the structure is reduced to a great extent. Ozay (2005, pp.845-846) and Hinrichs (1987) added that the heat created by the sun patches formed in the courtyard is either absorbed by the ground or causes evaporation through the bricks which are always wet either from the earth underneath. This helps to increases the comparative moisture of the dry air and lowers its increased temperature. By being exposed to the outdoors, the courtyard floor loses heat by long-wave, outgoing radiation.

This radiative heat loss plays a role in decreasing the climate of the courtyard ground and consequently the layer of air it is in contact with; it reduces the temperature of the neighboring lived in rooms and spaces to enhance the thermal comfort, (Figure 2.29).
Moreover, many details in vernacular house were also, response to the environment, for example the massive ceiling structure and construction of its shallow domes, there are arches and vaults which are built of brickwork in Basement. These therefore provide additional thermal insulation against heat gain in summer, to use the thermal inertia of the adjacent floor, and deep walls in providing relatively comfortable internal thermal environmental conditions (Al-Azaawi, 1984 pp.76-77). The parapet wall that included opining allows cross-ventilation and air-movement to take place through it. These projects have the advantage of losing their heat to the atmosphere by radiation and convection immediately after sunset (Sozen and Gedik, 2007, p.1812). The pathway partially protects the habitable rooms and spaces on the ground floor from harsh weather (Agha, 2019; Moradi and Akhtarkavan, 2008, p.25). Incidentally, Dilia et al. (2010, 2011) highlighted the location of windows at high level also helps to avoid glare from the external ground. In relation to the house, the lesser exposure of the outside walls means the better it is able to fight the scorching heat. Also, it helps to reduce thermal gain to the interior in summer. Agha (2019) stated that the ratio of the void to solid over of the walls in courtyard elevation is very small for lived in rooms used in the hotter season to reduce to the minimum the amount of thermal gain both from the sun and from the hot and dry external surroundings. At the same time, this ratio is relatively large for habitable rooms used in the cold season to encourage thermal gain from the sun; this heat gain helps to warm the interior.

Seasonal use of spaces: In the summer, the 1st floor generally left unused; this allows the entire floor to act as a barrier against the solar gain in the ground floor's habitable spaces (Al-Azaawi, 1984; Agha, 2019). This is besides the seasonal use of space as mentioned in the architectural factors.



Figure 2.29: *Using natural materials in Vernacular house, Baghdad. (Researcher).*

Winter Thermal Comfort Strategies in vernacular houses:

This section is considered those techniques and strategies that are intended to influence the winter thermal comfort that will be considered. As has already shown in the literature, the vernacular houses are occupied in a manner that is responsive to the changing climate with spaces specially designed and used at the extremes of climate, hot and cold times of the year (Salman, 2017; Agha, 2019).

Table 2.16 shows the passive heating strategies for winter in houses in Baghdad.

Table 2.16: *The winter design strategies in vernacular house in Baghdad*

Passive heating strategies(Winter)

• Solar Gain
• Protection from the Rain
  o Urban Scale
  o Building Scale
• Protection from wind.
  o Urban Scale
  o Building Scale
• Seasonal Use of Space

Researcher depend on the literatures review (Warren,1982; Warren, 1984; Fethi,1982; Al-Azzawi,1984; Al-Kaisi ,1984; and Agha, 2019)

Solar Gain: The insulation of the inner walls of the vernacular houses maintains heat during the winter and provides residents with comfortable thermal conditions during the cold winter days (Agha, 2019). The insulation on the roof terrace prevents summer heat gain and winter retains heat (Agha, 2019).

For habitable areas used for wintertime inhabitation and located mainly on the first storey, this ratio is relatively big in order to facilitate direct solar heat gain to the interior to make it warmer (Ozdemir et al. 2008, p.971) The reasons for this ratio were confirmed by Sozen and Gedik (2007, p.1814). These are: to allow the sunlight in winter to penetrate deeper into the interior and therefore produce a relatively warmer internal thermal environment; to provide adequate cross-ventilation through in the upper floor, particularly overnight in the spring and autumn.

Protection from the Rain and wind\ Urban Scale: Due to the urban layout compactness of the vernacular houses, in winter, the closeness of the houses protects one another from rain and wind.

Protection from the Rain and wind: Building Scale: A negative aspect of the design for the winter context is that all livable spaces and rooms view inwards towards the courtyard, by opening windows and doors to this external space (Al-Azzawi,1984; Agha,2019). They are cold during the winter because of the heat loss by these external walls, doors and windows as well as by ventilation losses through the doors and window (Al-Azzawi,1984; Agha,2019).

In the case of the winter situation, however, the building shape is less effective, with each room having at least one exterior wall, with related heat loss via loss of conductions and ventilations (Agha, 2019).

Seasonal Use of Space in winter: In the past, the main winter rooms located on the courtyard's northern-western end, allowing for solar gain (Al-Azzawi,1984; Agha,2019). This shows the significant role climatic conditions and passive strategies design played in the planning of the vernacular courtyard houses (Al-Azzawi,1984; Agha,2019). The occupants have played a vital part in their seasonal movements.

As evidence from the literature show that the vernacular house in Baghdad is response to the changing of environmental condition such as the air movement and air flow of wind, the sun light, and also the change in temperature vernacular Courtyard houses during the day and seasons to promote the house performance.

It should be noted that much of this literature is quite old. Hence the question remains as to what extent that the environmental strategies remain valid / effect in the existing contexts. As such, it is required to understand the existing environmental requirements performance and thermal comfort of the occupant for understanding the existing states of play and so inform emerging contemporary vernacular design strategies.

2.4.4 Evolution of the city: Transition to Contemporary architecture and urban patterns:

There is a consensus that after the drastic shift in technologies and energy resources in Iraq, particularly in the last century, the vernacular patterns of streets, domestic buildings,

households, and labour in the cities have changed within tens of years, while these changes have occurred over hundreds of years in the earlier centuries (Al-Kaissi, 1984; Al-azzawi, 1984; Oliver, 2003; Nooraddin, 2004; Salman,2017; Agha, 2019). All of these changes have influenced the way that vernacular houses and their elements are used at present and resulted in the creation of building types which are fundamentally different from vernacular ones. The following sections explain some of these changes.

1. ***Change in street systems:*** Until the beginning of the last century, the traditional street system in Baghdad has based of pedestrian movements. It has unique distribution patterns of narrow and twisting streets, besides ended into groups of buildings (Agha, 2019). Upon that pattern which had evolved over long periods according to strong social and environmental rationalities, was imposed an orthogonal network of roads for modernisation (Nooraddin, 2004). Muddy alleys were replaced by asphalt streets. The newly built streets were increasingly lined with shops, which tended to compete with the bazaar for customs. With the arrival of electricity, beginning of the twenty century, and the establishment of a street-oriented urban culture, new forms of socialisation emerged, and Baghdadis, more than ever before, grew familiar with modern concepts of time and leisure such as strolling in the street, bicycling and public interaction on the pavements of the new streets (Salman, 2017). The dimensions of the modern Iraqi city, as a result of increasing population and falling development densities, became greater than was convenient for pedestrian activity (Agha, 2019; Nooraddin, 2004). As distances become comparatively great, intra city travel was increasingly done by vehicle, and distance or mobility became an important dimension in everyday life (Agha, 2019; Nooraddin, 2004). Vehicular travel became general, and a road system became the essential structuring and orienting element of new development or large-scale renewal. Wide new avenues for motorised vehicular traffic were cut through the old, compactly structured urban texture (Nooraddin, 2004; Al-Kaissi, 1984) and led to a fundamental change in building patterns. As part of the process of modernisation; new streets were introduced which cut through existing fabrics. The basis for the urban transformation of Baghdadis was this new street pattern with its avenues and

squares. The wide, straight thoroughfares further enabled another important aspect into the transformations: the new building style along those roads. The key associations of this process were the establishment of various street life and the different indoor and outdoor relationships (Agha, 2019; Nooraddin, 2004).

2. ***Change of building patterns – orientation, materials and form:*** Even though the general changes in Iraq, vernacular architecture managed to continue in the twentieth century. It is still evident in some old Baghdad neighborhoods today. Such vernacular buildings played a significant role as a source of knowledge and design concepts in local architecture.

   Changes in building form in Baghdad were generally associated with the change in the street system (Nooraddin, 2004). Al-Kaissi (1984) claims that the motor car was the most significant factor that transformed the Baghdadis residential environment in the twentieth century, during which pedestrian access was segregated from vehicular access, and the traditional relationship between the house and the street was completely transformed (Agha, 2019). The orientation of the buildings was largely determined by the orientation of the street system (Agha, 2019). The new system of land subdivision, the rationalisation, and standardisation of the size and shape of land parcels, which was consistent with the orthogonal blocks and streets, led to new building forms (Figures 2.10 and2.11). The arrangement and layout of the new housing areas are much more standard, clearly resulting in the more formal subdivisions of large land tracts and a technical approach in houses designs and constructions.

   The development of the new building form was, as the new street pattern, part of a package of goods, ideas, and images imported from the West (Agha, 2019; Nooraddin, 2004). Baghdad Houses underwent significant changes after the First World War and increased dramatically after the Second World War. For the reason that Baghdad is the capital city and centre of power, it experienced architecture changes and urban transformation and the introduction of new architectural styles before others Iraqi cities, and consequently influenced the introduction of contemporary architecture elsewhere in the country (Agha, 2019; Nooraddin, 2004). According to Nooraddin (2004), in the city of Baghdad, the transition from vernacular patterns to contemporary ones began to take place in 1922. A transformation in the concept of the arrangement

of spaces around a courtyard occurred, and the spatial pattern of the dwelling unit changed. No longer was an internally oriented architecture in style in new dwellings (Agha, 2019; Nooraddin, 2004) (Figure 2.27). The pattern of a courtyard was abandoned; the vernacular courtyard was replaced by a courtyard close to the street, behind or in front of the house (Agha, 2019; Nooraddin, 2004). The courtyard, once an oasis of city streets, was no longer a main element in Baghdad's new constructions. As stated by Warren and Fethi (1982) "Like the city, the house changed sudden creating disunity between people's past and present built environments" (Salman, 2017). The contemporary house has an extroverted form, which changed the way people lived in Baghdad. The continued pressure from the growing population on urban spaces and the development of Western dwelling styles of two-story terraced houses and multi-story flats have led to a new housings morphology and a shift from low-rise, inward-looking courtyard house to outward-looking medium- to high-rise apartments. (Nooraddin, 2004). New, non-vernacular dwellings, also called"contemporary" (Agha, 2019) and "modern" (Nooraddin, 2004), became generally smaller, and a culture of living in flats developed (Agha, 2019; Salman, 2017). These houses represent a complete stylistic break from the vernacular courtyard house, with the central living area now covered (Agha, 2019; Salman, 2017). These aspects are further investigated and discussed in section 2.5.1.

3. ***Change in households:*** In the end of the nineteenth century in Iraq, the economic necessity of large, extended families declined. The patriarchal economic structure of the extended family was undermined by the weakening of the traditional sources of income on which it was based. Money in the community shifted into the hands of young workers, juniors in the old family hierarchy. These younger members often chose to live independently. They left the older generation behind in their neighbourhoods, villages, and towns. The pattern of household structure and central family unit in Iraq changed rapidly from that of large extended families to small nuclear families in the twentieth century (Agha, 2019). This dictated the smaller sizes of houses (Agha, 2019; Salman, 2017) and as a result meant a demand for more dwellings for the same number of people (Agha, 2019). This demand was also triggered by increasing living standards and rising expectations, as well as population

growth (Salman, 2017). High land prices also led to the development of smaller and smaller dwellings (Agha, 2019).

4. ***Vernacular courtyard houses and new occupation patterns:*** In the process of modernisation, vernacular houses also underwent extensive changes. They usually belonged to affluent people who moved to newer sections of the city in search of a better quality of life (Agha, 2019) and adaptation to modernisation. The assumption of a lower quality of life in vernacular neighborhoods was the result of many factors. These neighborhoods did not have enough urban facilities, such as leisure centers, parking, and green space, good public transport and good accessibility for cars. Moreover, the existence of low-quality and unsafe structures in buildings, and the replacement of the original residents with migrants from lower-income/ cultural classes who had less attachment to the neighborhood accounted for the lower quality of life in these neighborhoods (Agha, 2019; Salman, 2017). Accordingly, many vernacular houses and neighbourhoods lost their weal their residents. Some large vernacular courtyard houses have been used for multi-occupancy renting, which could be a source of income for the family or accommodation for the household's offspring (Agha, 2019).

   From time to time, if the owner died, the house would be passed on to many beneficiaries who would never return to the house. Under those circumstances, the house might be rented out to immigrants, perhaps several families. Case in point of this could still be seen in areas such as Al-Kadhimiya and Al- adhamiya, which accommodate large numbers of refugees from other cities. Immigrants were drawn particularly to the historic centers due to the abundance of large houses and the number of empty properties (Agha, 2019). Under those circumstances, generally, little or no repair was carried out, and the houses suffered a great deal of deterioration (Nooraddin, 2004). Moreover, sometimes the house was sold to state organisations, and the function of dwelling units was altered to governmental offices, museums or even higher education buildings, such as the house museum in Baghdad.

5. ***Vernacular dwelling in the present day:*** Despite the changes, which have occurred in Iraq, examples of vernacular houses still exist in old neighborhoods of many areas in Baghdad (Agha, 2019). However, considering the impact that all these and other

changes might have introduced to individuals, families, and society at large, the probability of a continuing close match among designs and user's requirements in the vernacular house is rather doubtful and requires more explanation as well as exploration, and systematic practical effort. Despite the existence of a situation where the vernacular houses have seen to be in a state of decline or at risk of being replaced by modern counterparts or used for new purposes, those houses are still cited in academic literature as models of culturally acceptable and sustainable practices. To find out more about this paradoxical circumstance, we need to know not only about the buildings themselves but as well about the attitudes and opinions of the actual users of these buildings.

2.4.4.1 Contemporary houses – background and context

The contemporary house is typically of two storeys. Contemporary houses are usually detached or semi-detached, with a larger surface area, which leads to greater exposure to solar radiation and wind than in vernacular houses; this gives these houses more solar energy, raising their thermal load. Furthermore, the newer house designs neglect the use of passive design techniques but depend mainly on mechanical systems. Today, houses in Baghdad do not represent the Baghdadis' vernacular styles in any way. With their new structures and shape, the residents' way of thinking in relation to their homes has changed. In Baghdad's latest constructions, the courtyard, which was once the core characteristic of the city's streets, is no longer the most important part of the house. Findings from the literature show that installing as well as operating air-conditioning systems were the most major strategy applied for providing thermal comfort in contemporary houses. There are no adopted uniform building energy standards in Baghdad (UN-Habitat, 2006). However, the contemporary houses are not highly successful in dealing with climatic as well as environmental strategies. The microclimate of the modern house changed compared to a vernacular one, because of the change in its capacity, location, windows, and the thermal resistance and heat capacity of the building (Agha, 2019). By dependence on mechanical cooling and heating systems in housing and the extensive use of private vehicles have brought many issues, for instance, extensive

energy consumption, fuel depletion, air pollution, global warming contributing. This rises the needs of re-evaluating the use of appropriate new technologies.

Baghdad became urbanistically chaotic as a result of the absence of stylistic uniformity in buildings in some aspects, for example, the relationship of the building with their environment. As people have vernacularly reached the built forms through trial and error (Rapoport, 1969), then and there I can argue that in Baghdad now there is no successful set of design strategies that people can take for established their houses.

Table 2.17 shows the main spatial elements of the contemporary houses in Baghdad, as a case study.

Table 2.17: *The main spatial elements of the contemporary houses in Baghdad*

Houses' elements or features	**The effective factors**	**The direct impact**
Design	• 3 side attached • detached or semi-detached, with large glazed areas and bigger surface area	**-**
Entrance	-	
Garden	Views	Views Natural ventilation
The internal spaces	Dimensions for the interior space(height, length and width)	Natural ventilation
	Top floors remaining largely unused in summer days	The floor behaves as a shelter from any solar-gains
The wind – tower (Badgir)	-	
The large windows instead of Shanasheel	Openings large size and location	Natural ventilation Garden view
	Louvers + Screens\in some homes	shading
The building envelope	Brick walls or Concrete walls	Heat gain
The water& planting elements	-	
The building form	-	
Envelope design \Exterior wall	the exterior walls of contemporary houses made of supported bricks or concrete with a thickness of 24 cm, but not thermal insulation in the day time nor storage or delay heat transfer at night.	

Source: Researcher, summary from literature

Table 2.18 shows the affective factors on the contemporary house performance

Table 2.18: *The affective factors on the contemporary house performance*

Elements or features	The effective factors	Ref.
The garden instead of courtyard	Views	(Salman 2017, Agha, 2019)
The internal spaces	Dimensions for the interior space(height, length and width)	(Warren, 1984; Fethi,1982; Al-Kaisi,1984; Agha, 2019)
	Top floors remaining largely unused in summer days	(Al-Kaisi,1984; Agha, 2019)
The wind – tower (Badgir)	Not applied	
The large windows instead of Shanasheel	Openings large size and location	(Salman 2017, Agha, 2019)
	Louvers + Screens\in some homes	(Salman 2017)
The building envelope	Envelop thermal mass (Low thermal mass)	(Salman 2017, Agha, 2019)
The water& planting elements	-	
The building form	-	

Source: Researcher, summary from literature

It could be suggested that contemporary houses are thus "extroverted" (Salman,2017; Nooraddin, 2004); constructed without a courtyard, mean that all rooms face the street, with openable windows onto the streets (Agha, 2019). It is said that, even in vernacular house, there has for the first time, as an indication of modernism by some, the tendency to open windows in the outside walls facing the passageway (Agha, 2019; Nooraddin, 2004), Figure 2.31. In addition, at least one vehicular entrance to each property became vital because of the Northern and Southern orientation being refined. New housing layouts and car parking were constructed (Salman, 2017; Agha,2019) in such a way that there is now usually at least one parking area to each house since the twentieth century. Nearly all new dwellings have directed access to the linear street provided for pedestrian and car access to the plots (Agha, 2019; Nooraddin, 2004). Morton claims (2008) that, in the Middle East and Africa, the earth buildings have replaced by buildings that made of

concretes and steels because "these materials symbolise the modernising progress to which people commonly aspire"(Morton, 2008). Though, this hasn't been the only reason in the Baghdadi houses.

There was a change in the way courtyards looked, they were no longer low-rise and inward looking, but were high rise outward looking accommodation (Nooraddin, 2004). This was due to the burden from the increased demographics and the launch of 2-storey terraced homes and blocks of flats (Nooraddin, 2004). New, non-vernacular dwellings, also called "contemporary" (Agha, 2019) and "modern" (Nooraddin, 2004), became lesser, and more people decided to live in flats which became the norm. New or modern dwellings consist of a living area, more than one bedrooms, kitchen and the bathrooms around a central roofed hall. Exterior and interior walls, as well as roofs, are constructed of baked brick, plastered inside with gypsum plasters (Agha, 2019; Salman, 2017). These houses represent a complete stylistic break from the vernacular courtyard house, with the central living area now covered (Agha, 2019). Furthermore, rather than relying on communal facilities, it became quite common for houses to include bathrooms and toilets. Solid fuel choices for space heating were gradually changed with gas and then electrical appliances (Agha, 2019). The microclimate of the modern house changed compared to a vernacular one, because of the change in its capacity, layouts, location, windows, as well as the thermal resistance and heat capacity of the building (Agha, 2019). A big change occurred in Iraq during the 1970s: swamp coolers (air-cooling system) were introduced, which have been used since then (Water air-cooling center in Baghdad, 2019). The air cooler is installed on the house roof. It consists of an electrical fan, which draws outside air into the room across water-soaked straw panels, thus introducing cooled air with considerable water content. Such coolers are widely and popular used in Iraqi houses (Salman, 2017). The popularity of air-cooling systems relates to numerous factors: simplicity of installation; effectiveness; low initial, operational and maintenance costs; elimination of dust, dirt and flies (compared to traditional cooling systems); and the lower rate of energy consumptions, compared to air-conditioning systems (Water air-cooling centre in Baghdad, 2019). Air-cooling systems seem to work well with the hot climate but suffer from the drawback that in Baghdad, as in many other of the Middle East cities, in

the mid-afternoon in summer times, when the highest loads are placed on the electricity supply systems, frequent power failures occur (Water air-cooling center in Baghdad, 2019). In addition to the power failure risks, the extraordinary levels of humidity which swamp coolers provide (Givoni, 1984) have often observed upon by Baghdadi to be harmful to health, causing cold and rheumatism (Agha, 2019). Moreover, these swamp coolers sometimes are considered to be a "noisy and unsightly protuberance" on buildings (Ghiabaklou, 2001).



Figure 2.28: *The contemporary houses in Baghdad (Researcher)*

2.4.4.1.1. The factors effective in providing comfort in contemporary houses: thermal and socio-culturally factors

Various factors will be reviewed below and as well have been considered across this research chapters as the most significant issues for the inhabitants of that house types.

The themes below will be review within the research, common to the structure applied for vernacular housing, enabling later comparison:

- Urban design factors.
- Architectural factors.
- Environmental factors.
- Socio-cultural factors.

Urban design factors: This section presents literature findings on urban fabric factors related to contemporary area, which affect the satisfies the needs of the occupants. This section examines the literature review results on the extent to which urban fabric of the contemporary houses satisfy the needs of their occupants in an environmentally and social-cultural ways. It has been found from the literature that the urban fabric of contemporary areas has wide street and the car easy and direct to access to the house because of the wide street design (Figure 2.31). For dwellers of contemporary homes, analysis showed that residents were content about their neighborhood and also socialized with them (Nooraddin, 2004; Agha, 2019). However, this socialization was not as frequent as the residents of vernacular homes. Further details of the urban design strategies associated with contemporary housing, as noted in the literature, are given in Table 2.18.

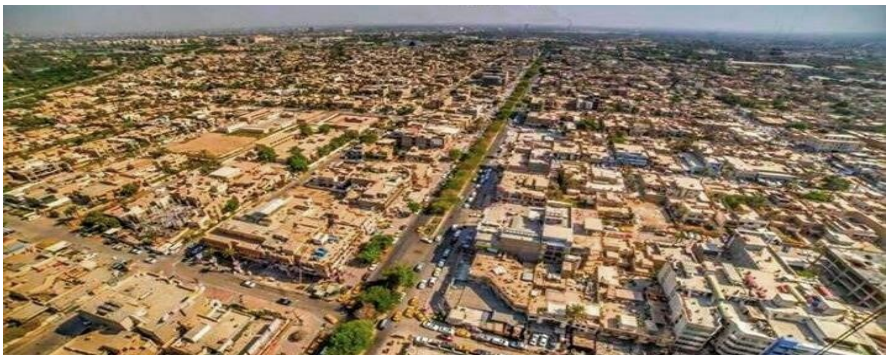


Figure 2.31 : *Changes in housing patterns in Baghdad were generally connected with the change in the street layouts, Baghdad city(Google map, 2020)*

Table 2.19 Shows the urban design strategies of the vernacular houses.

Table 2.19: *The urban design strategies*

Design strategy		Description	Ref.
Urban fabric aspects	**Density and street layout**	It has been found from the literature that the urban fabric of contemporary areas has wide street and the car easy and direct to access to the house because of the wide street design.	(Salman 2017, Agha, 2019)
	Orientation	The orientation of the contemporary house wasn't formed follow according to the socio-culture effects or the bioclimatic regions. There is no consideration to orientation in designing the houses towards "qibla". Moreover, the street layout in contemporary areas based on grid layout results in a high percentage of the rooms being poorly oriented. In many cases, the highly inhabited spaces are located in the wrong orientation for passive solar control.	(Warren, 1984; Al-Kaisi,1984; Nooraddin, 2004;Agha, 2019)
	Outside zone	The contemporary house has a front garden, which is an outside space, rather than a courtyard. The front garden is used for social gatherings with family or neighbours and does not provide any privacy for the occupants. Some contemporary houses have an extension area to the bedroom or living room which is semi-covered with flowers and shrubs. This space does not offer the same characteristics as a courtyard because it does not provide any sense of enclosure. It reflects the characteristics of a modern garden rather than a courtyard. Therefore, contemporary houses do not fulfil the occupants' needs in terms of privacy from neighbours and passers-by.	(Al-Kaisi,1984; Nooraddin, 2004; Agha, 2019)

It can be seen from Table 2.19 and Figures 2.31 that the urban design of the contemporary house is simplistic when compared to the vernacular house, while the relationship with the climate is limited explicit.

Architectural factors: In terms of architectural aspects, the contemporary house could be seen to retain the roof terrace being a functional design strategy in common with vernacular courtyard houses; but, the houses are typical of two stories. Furthermore, the strategy for seasonal variation in the usage of spaces does not any longer see in the occupation pattern of contemporary houses, behind the roof terrace used for sleeping in the summer times. Table 2.20 shows the architecture design strategies in contemporary houses.

Table 2.20: *The architecture design strategy in contemporary houses*

Design strategies	
Architecture design aspects	Form design
	Window design
	Glazing design
	Envelope construction
	Roof terrace

Form design: In the contemporary Baghdadi houses, the issue is different than the vernacular houses. The shape of the contemporary house wasn't formed follow according to the socio-culture effects or the bioclimatic regions. The contemporary houses are usually detached or semi-detached, with bigger surface area, which exposes more to solar radiation and wind than vernacular houses do; this gives these houses more solar energy, raising its thermal load. Furthermore, the newer house designs neglect the use of passive design techniques but depend mainly on mechanical systems (Nooraddin, 2004; Agha, 2019). Today, houses in Baghdad do not represent the Baghdadis' vernacular styles in any way. With their new structures and shape, the resident's way of thinking in relation to their homes has changed (Agha, 2019). The courtyard was not the most important part of the house anymore in Baghdad's latest constructions which was the core of the streets in the city at one point.

Window design: In modern era, the separation of houses and the different pattern designs have created contradiction with the bioclimatic and socio-culture effects of windows in such a context. Windows in contemporary house no longer facilitate cross ventilation nor are they designed to deal with visual intrusion as was the case in the vernacular house. In Baghdad, as a case study, large glazed, unshaded and visually unprotected windows have become a distinctive feature of the contemporary house contributing to the high energy consumption in buildings (Nooraddin, 2004; Agha, 2019).

Windows glazing: Large glazed windows have become a distinctive feature of the contemporary house contributing to the high energy consumption in buildings (Nooraddin, 2004). The use of double glazing is common in some houses but the majority use single glazing with (Nooraddin, 2004; Agha, 2019). The problem with large glazing windows is that they are usually not protected from solar heat by using an appropriate shading device (Nooraddin, 2004). The shading devices are the most effective passive design strategy, which used in the vernacular house (Nooraddin, 2004; Agha, 2019). The reason the glazed surface does not shade seems to be that this large fenestration area needs a large shading device for effective shading

Envelope construction: The exterior walls of contemporary houses made of supported bricks or concrete with a thickness of 24 cm, but not thermal insulation in the day time nor storage or delay heat transfer at night (Al-Kaisi,1984; Nooraddin, 2004; Agha, 2019).

Roof terrace: It has been found from the literature that the terrace of the roof in the contemporary house does not offer complete privacy to the inhabitants during summers for sleeping at nights. The parapet wall and its height do not allow the prevention of peeking from neighbours (Nooraddin, 2004; Agha, 2019). Also, the area of the contemporary house roof is big enough to do various activities, but they don't use it for any (Nooraddin, 2004; Agha, 2019).

Socio-cultural factors: In opposite to the socio-cultural responsive driven design of vernacular housing, the contemporary houses influenced with western style design.

From the literature, as such it can be found that the houses are less designed to respond to those traditionally valid socio-cultural norms. Table 2.21 below provides descriptions of contemporary housing design approaches in Baghdad.

The following design strategies will be discussed and illustrated below:

- Entrance (Mejaz);
- garden instead of courtyard;
- Rooms outwards looking to the garden;
- Large windows;
- Mix gender visitor;
- Roof terrace.

Table 2.21: *Socio-cultural factors in contemporary house*

Socio-cultural strategies	**Descriptions**
Entrance	Not Available data in literature review
garden instead of courtyard	• provide social space with family or neighbours. • No privacy.
Rooms outwards looking to the garden	The rooms and spaces look outwards toward the garden
Large windows	No privacy
Mix gender visitor	There are no split of gender visitor in contemporary house.
Roof terrace	Because of unnecessary glancing by neighbors, it is possible that a complete privacy is not offered by the roof terrace.

Source: Researcher, summary from literature

Garden instead of courtyard



Large windows



Mix gender visitor



Roof terrace



Figure 2.32: *Socio-cultural factors in contemporary house*

The literature review indicates that the contemporary homes are not fashioned for satisfying the socio-cultural requirements for inhabitants regarding the provision of complete privacy in both terms of preventing neighbours overlooking.

Environmental factors in contemporary houses: The literature findings indicate that the contemporary houses have less success in responding to the location's environmental demands. However, the most critical technique and strategy applied to contemporary

houses for providing thermal comfort is the installation and operation of air conditioning units.

Summer environmental (Overheating Prevention) Strategies in contemporary houses:

It has been found from the literature that the contemporary houses do not have habitable spaces and rooms which have specially designed for summer habitation. Moreover, all the habitable spaces and rooms are designed to be used by the inhabitants during all seasons (Agha, 2019; Al-Azzawi 1984). As previously mentioned in this chapter, Iraq lies in the hot-dry region, where the relative humidity is very low in the summer, and the winter is cold or mild, moreover where summer daytime temperatures maybe about 50 °C in some areas, as is observed in Iraq. However, the most critical technique and strategy applied to contemporary houses for providing thermal comfort is the installation and operation of air conditioning units. Table 2.22 shows the design strategies in contemporary house in Baghdad

Table 2.22: *The design strategies in contemporary house in Baghdad*

Summer strategies	
• Self-shading: o Urban Design Scale o Building scale	The result of the site plan of contemporary housing development in Baghdad, where the contemporary houses are built in detached or semi-detached forms, the houses are not offering beneficial shadings to each other.
• Dust storms	As for the vernacular houses, the contemporary houses are exposed to the spring/summer dust storms. But, it isn't possible to shelter the garden in order to provide protection for the occupants. During the dust storms, the windows and the doors have kept shut.
• Thermal mass.	Constructions are of relatively low thermal mass.
• Earth Shelter: basements.	-
• Natural ventilation systems: Badgir (wind-tower).	-
• Using different spaces in different weather that enable function response to climate	In the summer, the first floor is generally left unused; this allows the entire floor to act as a barrier to solar gain in the ground floor's habitable spaces. There aren't other aspects of this strategy.

Researcher depend on the literatures review (Agha,2019; Al-Azzawi,1984; and Al-Kaisi ,1984)

Winter Thermal Comfort Strategies in contemporary houses:

This section is considered those techniques and strategies that are intended to influence the winter thermal comfort that will be considered. As has already shown in the literature, the vernacular houses are occupied in a manner that is responsive to the changing climate with spaces specially designed and used at the extremes of climate, hot and cold times of the year (Salman, 2017; Agha, 2019). However, the most critical technique and strategy applied to contemporary houses for providing thermal comfort is the installation and operation of air conditioning units.

Table 2.23 shows the winter design strategies in contemporary house in Baghdad.

Table 2.23: *The design strategies in contemporary house in Baghdad*

Winter strategies	
• Solar Gain	The insulation levels of the walls of the contemporary house does not keep the heat during the winter to provide residents with comfortable thermal conditions during the cold winter days.

• Protection from the Rain
  o Urban Scale
  o Building Scale
• Protection from wind.
  o Urban Scale
  o Building Scale
	Due to the urban design layout of the contemporary houses, they are exposed to the negative effects of the winters wind and rain.

• Seasonal Use of spaces	No application

Researcher depend on the literatures review (Warren,1982; Warren, 1984; Fethi,1982; Al-Azzawi,1984; and Al-Kaisi ,1984)

Solar Gain: The insulation of the inner walls of the contemporary house does not keep the heat during the winter to provide residents with comfortable thermal conditions during the cold winter days.

Protection from the Rain and wind: Due to the urban design layout of the contemporary houses, they are exposed to the negative effects of the winters wind and rain.

The literature findings indicate that the contemporary houses have less success in responding to the location's environmental demands. The available literature age is less of a concern as the limits discussed refer to passive design strategies, particularly solar shading and the thermal mass uses, which could assist to decrease the energy demands for air conditioning if they were to be included into contemporary housing design. However, it is critical to found to what extent the passive strategies, in this context, could be effective.

2.4.5 Comparison of vernacular and contemporary houses in Baghdad

This study needs a comparison among the aspects of the vernacular houses in Baghdad with the relevant aspects of contemporary houses to identify and classify the architectural aspects, environmental aspects, as well as socio-cultural aspects of the vernacular and contemporary houses in Baghdad.

The following themes will be reviewed within this section:

- Comparison of vernacular and contemporary house for urban design and architectural factors.
- Comparison of vernacular and contemporary house for environmental factors.
- Comparison of vernacular and contemporary house for the sociocultural factors.

2.4.5.1 Comparison of vernacular and contemporary house for urban design and architectural factors

Domestic architecture in Baghdad, it may be said, is a product of one particular society and reflects both its predilections and its language. In general, typical dwellings, which are mostly one- or two stories in height, can be grouped into two categories:

1. ***vernacular courtyard housing*** within a compact layout serving mixed social classes and different standards of living. This kind of fabric is usually found in the older parts of cities, such as the center of Baghdad. This kind of housing discussed in section (2.4). Unfortunately, large areas of vernacular houses have been ruined due to incorrect policies, by poorly-informed local authorities and poor advice from the main government body. As a result, there is a lack of continuous positive examples, and the conditions of the houses still standing remain poor and in great need of protection (Agha, 2019; Al-Azzawi, 1994, p1099).

2. ***contemporary housing*** within a loose layout including more open spaces in the form of gardens surrounding each house, wide roads and playing fields close by. Post 1952, the outer part of Baghdad vernacular and contemporary houses were introduced. Socially, this kind of construction segregates social classes in different spaces, according to economic and social status. Such modern developments are usually found in the more recently developed parts of cities and are built by both government and the private sector. They each provide housing for low and middle-income families and the private sector, also, provides housing for the rich.

The section (2.4.3) shows that vernacular houses in Baghdad contained many indications of the life lived within them and the unique ways in which they satisfied people's physical and social requirements within the resources available to them. The vernacular house of Baghdad is still one of the masterpieces of world architecture, due to its achievements and architectural solutions to climate adaption, in the form of thick mud-brick walls and a central courtyard (Agha, 2019). Vernacular houses have designs which align the natural resources with the thermal conditions in a way that provides comfort for the inhabitants.

However, the last century witnessed a dramatic change in technologies and energy resources, and this enabled the thermal tasks to be done by additional systems (i.e. mechanical air conditioning systems). This enabled architects to employ new designs paralleling the shapes of European and American houses. House is alien to the culture of the region and conflict with the needs of the inhabitants, especially with regard to controlling the indoor climate (warren&fethay, 1982). The characteristics of modern

housing systems can be classified as follows (Al-Kaisi, 1984; Al-Azzawi 1984; Noorden,2004; Aalhashem, 2008; Salman,2017):

1. The streets widen and contain large open spaces that facilitate the use of cars (Fig. 2.33). However, this exposes the roads to intense solar radiation and hot winds, which pedestrians want to avoid, chiefly by increased use of cars, which in turn reduces social communication and raises the levels of noise and pollution in the neighborhood;
2. The contemporary houses are usually detached or semi-detached, with large glazed areas and bigger surface area, which exposes more to solar radiation than vernacular houses do; this gives these houses more solar energy, raising its thermal load (Awni, 1979). Furthermore, the newer house designs neglect the use of passive cooling techniques but depend mainly on mechanical systems. All these raise the energy consumption of the houses and add to the pollution, even allowing for the beneficial effect of insulation and double glazing on the surface area, since such techniques are easier to use and more economical in a smaller vernacular courtyard house.

The residents travelled to a totally new neighborhood which meant they had to adapt to a new life style without their choice. This meant that the residents did not have the time to think about the effects this would have on the city. The courtyard was not the most important part of the house anymore in Baghdad's latest constructions which was the core of the streets in the city at one point. In their observations on Baghdadi development, John and Fethi (1982) write:

> *"Like the city, the house changed overnight creating disunity between people's past and present built environments. The modern house had an extroverted form, which changed the way people lived in Baghdad. This has created many issues for Baghdadis who moved from the old town to the new suburbs. First was that of privacy – Baghdadis were used to a more private domain where the courtyard shielded them from the street. Suddenly, they found themselves in houses with a different spatial structure and privacy/public hierarchy. In reaction to this, some houses were designed with screens that covered larger glass*

windows to not only protect against the sun but also provide more privacy. Another issue was the emergence of the balcony, which due to Iraqi's hot and dry weather had no functional role whatsoever. After years of collecting dust many have been closed and were extended as additions to the house" (John and Fethi ,1982).

Today, houses in Baghdad do not represent the Baghdadis' vernacular styles in any way. With their new structures, the resident's way of thinking in relation to their homes has changed, (Agha, 2019), Fig. 2.42. By looking for ideas worldwide in designing their homes, today's domestic built environment for Iraqis reflects designs from different countries which has increasingly had an effect on people's way of living. These houses are environmentally high energy designed; using building components from outside of the country and relying greatly on water and electricity from the national network.

The demolition of Baghdadi vernacular buildings has created a vacuum, into which people from other countries bring in a range of architectural designs. When driving through the city, one can see that the homes reflect a range of styles such as Japanese, Mediterranean, Modern, Neo-Classical and Islamic. Rapoport's (1982) work called "The Meaning of the Built Environment: A Non-Verbal Communication Approach" gave a reason for this type of built environment to have taken root (Agha, 2019).

After the oil boom, the residents were in a stronger position to express their way of living in the villa, and at that point there were suggestions from around the world. However, these suggestions encouraged how others wanted them to live and not how they would want to live. The buildings in the city have been modernly molded without really understanding the effects. In addition, the authorities' hidden enthusiasm to create a state of the art and current image for Iraq has failed to preserve one of its own. However, some socio-cultural elements have remained despite the complete transformation of the Baghdadi house and people have adapted to change, referring this as the passive or active adaptation (Priemus, 1986).

Table 2.24 shows a summary of the hose changes in Baghdad.

Table 2.24: A summary of the house changes in Baghdad

	Vernacular		Contemporary	
	Features	**Advantages**	**Features**	**Advantages**
Urban Fabric	Compact	unity	Large areas \Iron grid Some old areas\compact	
		Climatic		
Street	Hierarchy	Diversity	Wide Streets	Suitable for cars
		Wind directing	Street Forestation	Shading
		Safety		Wind Breaks
	Narrow alleys	Shading		Dust traps
		Wind Breaks		Aesthetics
		Dust traps		
		Safety		
Housing	Inward looking	Privacy	3 side attached detached\semi-detached, large glazed areas, bigger surface area	• Thermal insulation • Garden view
	Courtyard	Enhance the inner climate	Garden	• Views • Natural ventilation
		Privacy		
	Entrance\ Mejaz	Privacy	Entrance	
	Thick walls	Thermal insulation	Brick walls or Concrete walls	Space investment
	Lack of openings	Privacy	Large windows +grills	Garden view
				Safety
	Shanasheel	Privacy		
		Sunlight control		
	Badgir	Wind catcher		
		Natural ventilation		
	Basement	Cooler inside		
	Roof terrace	sleeping		

Source: Researcher depend on literature

By tracking the different features and their benefits in each house in Table 2.25, it could be inferred that the needs which have been fulfilled in a vernacular house are ignored in

contemporary house which in its turn fulfilled other needs. For instance, a cultural need such as privacy was achieved in the vernacular house by many techniques and strategies, for example one of them was the lack of openings. Then in the contemporary house, when that has been replaced by large windows to provide a front-yard view, the privacy has been affected. Therefore, a need has been fulfilled on the expense of another. That applies to many other needs that could be drawn from the table.

Those needs are: Symbol of Privacy, Safety, Wind directing, Shading, Thermal mass, Suitable for cars, Aesthetics, Sense of development, Thermal Insulation, Safety & belonging, Better use of land, Enhance the Inner climate, Sunlight Control, Space Investment, Garden view.

Table 2.25: *Comparison of vernacular and contemporary house for urban design and architectural factors*

Strategies			**Vernacular house**	**Contemporary house**
Urban fabric factors	**Compactness and street layout**	**Compactness**	**Achieved**	**Not achieved**
		Walkability	**Achieved**	**Partly achieved**
		Wider street/ Car access	**Not achieved**	**Achieved**
	Orientation		**Achieved**	**Not achieved**
	Outside zone		**Achieved**	**Not achieved**
Urban fabric factors			**Achieved**	**Not achieved**
Architectural factors	Design		Both typologies of housing are capable of responding to the requirements in terms of scale as well as the type and number of required spaces.	
	Seasonal usage of spaces		**Provided**	**Not Provided**
	Architectural features		**Provided**	**Not Provided**
Architectural factors	Functional Program of usage		**Achieved**	**Achieved**
	Seasonal Program of usage		**Enabled**	**Not Enabled**

Source: Researcher

2.4.5.2 Comparison of vernacular and contemporary house for the environmental factors.

Environmental factors historically have found to be significant aspects to the peoples of Baghdad, where the designs evaluation of the vernacular houses were combined with passive strategies including the self-shading urban fabric design, shaded outside areas, strategies to provide shelter from dust storms, seasonal use of space, as well as the architectural synthesis of thermal mass, basement, and the natural ventilation methods.

This is in contrast to the contemporary houses, that doesn't incorporate the self-shading strategies from its planning, and whose provision of the garden instead of the courtyard doesn't offer protection against dust storms. The garden provision instead of the courtyard in itself doesn't preclude shading exterior areas-but it hasn't made clear in literature the degree to which this has a strategy applied to date.

The seasonal usage of the roof terrace as the sleeping areas provides shade and a buffer zone for the first floor bedrooms, as seems to be the case with vernacular house, to prevent the transmission of solar gain on the roof to the occupied ground floor areas.

Finally, in contemporary housing design, the passive design techniques and strategies, that are explicit in the vernacular houses, are all absent.

The following table 2.26 aims to compare housing 's environmental responsiveness as found in the literature to date. It should be noted that much of this literature is quite old. Hence the question remains as to what extent that the environmental strategies remain valid / effect in the existing contexts. As such, it is required to understand the existing environmental requirements performance and thermal comfort of the occupant for understanding the existing states of play and so inform emerging contemporary vernacular design strategies.

Table 2.26: *Comparison of environmental factors of vernacular and contemporary homes*

Design strategies			**Passive design strategies The direct impact**	**Vernacular house**	**Contemporary house**
Urban fabric aspects	Compactness and street layout	Compactness	Self-shade +Natural ventilation	Satisfied	Not Satisfied
		Walkability	Shading	Satisfied	Not Satisfied (Although possible)
		Wider street \ Car access	Natural ventilation	Not Satisfied	Satisfied
	Orientation		Natural ventilation and Heat gain	Satisfied	Not Satisfied (Although possible)
	Outside zone	Courtyard	Shading+ Natural ventilation+ Heat gain + Evaporative cooling	Satisfied	Not Satisfied
		Other aspects: Plant and water features		Satisfied	Not Satisfied
Architecture design aspects	Form		Heat gain+ Shading +Natural ventilation	Both typologies of housing are capable of responding to the requirements in terms of scale as well as the type and number of required spaces.	
	Window design	Size of window	Shading +Natural ventilation	Satisfied	Not Satisfied
		Shading device		Satisfied	Partly Satisfied
	Glazing design		Heat gain	Partly Satisfied	Satisfied
	Envelope design		Heat gain	Satisfied	Satisfied
	Roof terrace design		Sun shading +Natural ventilation	Satisfied	Not Satisfied
Environmental Factors				**Achieved**	**Not Achieved**

2.4.5.3 Comparison of vernacular and contemporary houses for the sociocultural factors.

Sociocultural factors historically have found to be essential to the individuals of Baghdad, where the inherent designs of the vernacular house with it inward-looking leading from the inner courtyard offers the inhabitants with complete privacies when they use it for their everyday activities as well as the social gatherings.

In addition, the entrance space (Mejaz) as well enhances privacy by separating the inside from outside. This detailed sociocultural responsive designs are also recognised in the provision with inhabitable spaces and rooms, with those designed to accommodate guests, especially male adult visitors.

Finally, the vernacular house's roof terrace is designed in detail to ensure occupants' privacies when used nighttime during the summer as sleeping areas.

It is in contrast to the contemporary houses that includes a garden that doesn't provide occupiers with complete privacies when they use the garden for social gatherings. The contemporary house doesn't have an entrance space (Mejaz), and as a consequence the guests and the occupants pass in the house from the same space, the open space (Tarma) at the front of the house.

The contemporary house doesn't include habitable room and space designed to receive visitors, especially male guests.

Finally, due to detailed design factors, the contemporary house's roof terrace has found not to provide privacy for the occupants when used nightly as a sleeping area in the summertime.

The following table 2.27 intends to compare housing's socio-cultural responsiveness, as mentioned in the literature to date. It should be noted that much of this literature is quite old. Hence the question remains as to what extent that the sociocultural factors may have evolved or changed. As such, it is required to understand the existing socio-cultural requirements in order to understand the existing state of play and so informs emerging contemporary vernacular housing strategies.

Table 2.27: *Comparison of vernacular and contemporary house for socio-cultural factors*

Socio-cultural strategies	**Vernacular house**	**Contemporary house**
Entrance	**Achieved**	**Not achieved**
Outside spaces	**Achieved**	**Not achieved due to detailed design concerns**
Interior privacy between genders	**Achieved**	**Not necessarily achieved**
Privacy for outside Sleeping Spaces(Roof)	**Achieved**	**Not achieved due to detailed design concerns**
Socio-Cultural Factors	**Completely achieved**	**Not achieved**

Source: Researcher

2.4.6 Examples of the synthesis

The desire to rethink the place and its identity that emerged after the widespread of the international style in Baghdad was reflected by many aspects such as; the climate, culture, etc., and heritage is one of them. Many projects of famous Iraqi architects have included elements that are drawn from vernacular Baghdadi architecture and heritage such as projects of Chadirji, Makiya, and others (El-Sheshtawi, 2004). The contemporary architecture in Baghdad is a mix between the vernacular and current technological advances which seems to work between the two different paths which are the most relevant for the current issue regarding architecture. To follow this concept, gaining knowledge of the value of heritage and traditional architecture as well as to appreciate modernity is important. They then need to take this on board and merge together to create their own identity. Before modern technology or mix modern and traditional trends, the followers used to have a ready-made model in place without any interference.

By roaming in Baghdad, one can easily find buildings that have vernacular feature but they do not give that impression of belonging to this particular city. In fact, they appear to be stuck on the elevation as decorative features that are not even working as symbols

as they are not integrated in the design of the building. Thus, that excludes the value and main characteristics of these features.

The Shanasheel shape is an example of a features that has been widely used during the 1980s-till todays in elevations to integrate the new buildings with the old ones. In vernacular design, the shanasheel was a way of achieving cultural need (privacy) in addition to controlling the penetrated light and air. Todays, it is often implemented in a way that excludes any value of it either by replacing the lattice wood screen with immovable glass or adding it as a decorative addition (Fig.2.33). Furthermore, even if its aesthetics meet some people's taste, it could not be a representative of the architectural identity of Baghdad.



Figure 2.33. *Using features as Decorative addition in Baghdad Provincial Council.*
Source: *Researcher (2018)*

Architects from Iraq such as Mohamed Makiya, Rifat Chadirji, Qahtan Awni and Hisham Mounir come close to revitalizing the vernacular architecture features, not by using formalistic adaptations but by taking the essential values and reconstituting them to suit contemporary needs. The following figures 2.34, 2.35, 2.36, and 2.37, categorize the inspiration from Vernacular Architecture mixed with modern techniques. The projects and design chooses of these four Iraqi architectures is a good example of

programmatically integrating vernacular features that have proven efficient over years into a modem and contemporary building programmer.

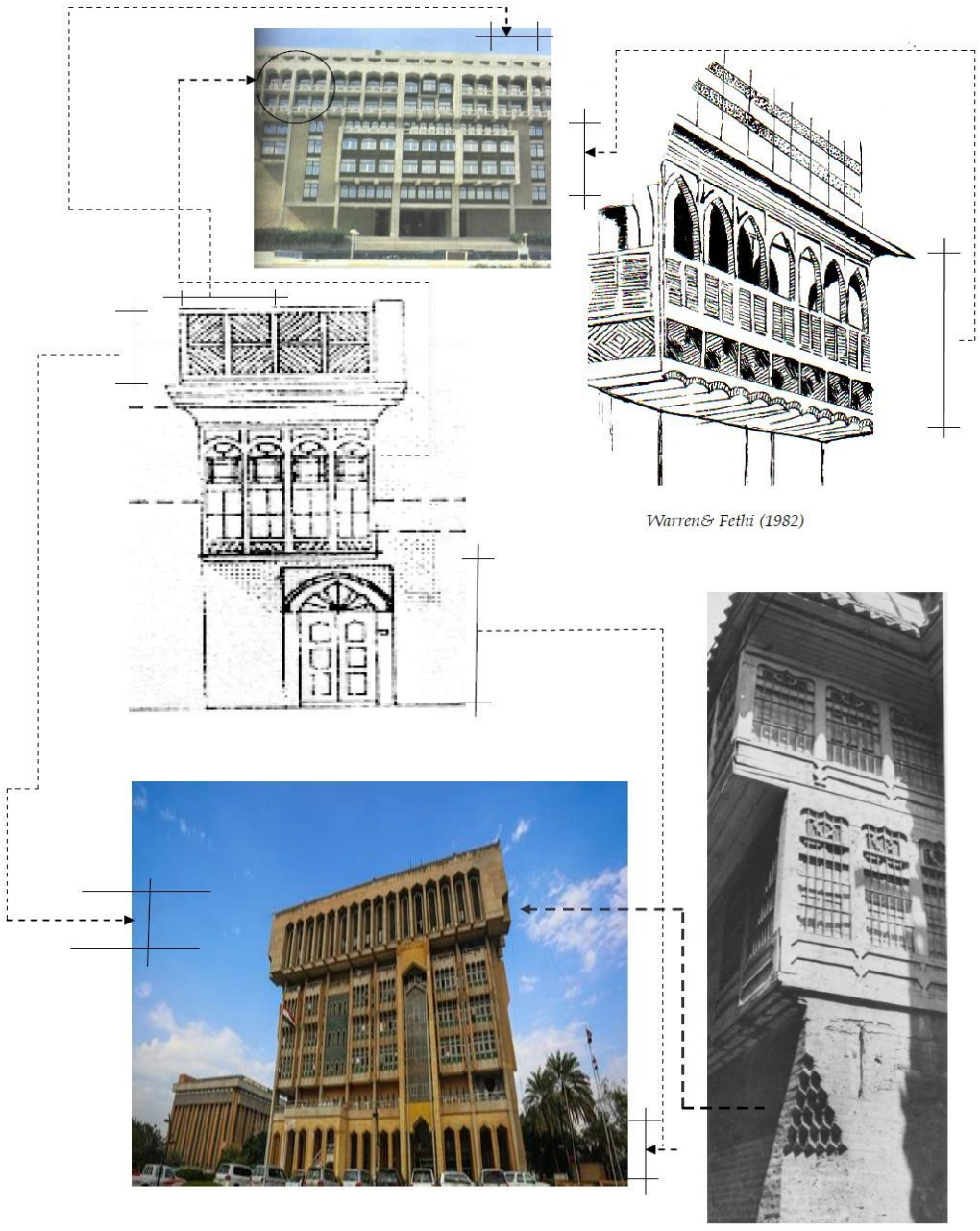


Figure 2.34: mayoralty of Baghdad, Hisham Mounir: the features inspiration between vernacular and contemporary

The figure shows the inspiration from vernacular architecture features(shanasheel) mixed with modern techniques.

Source: Researcher

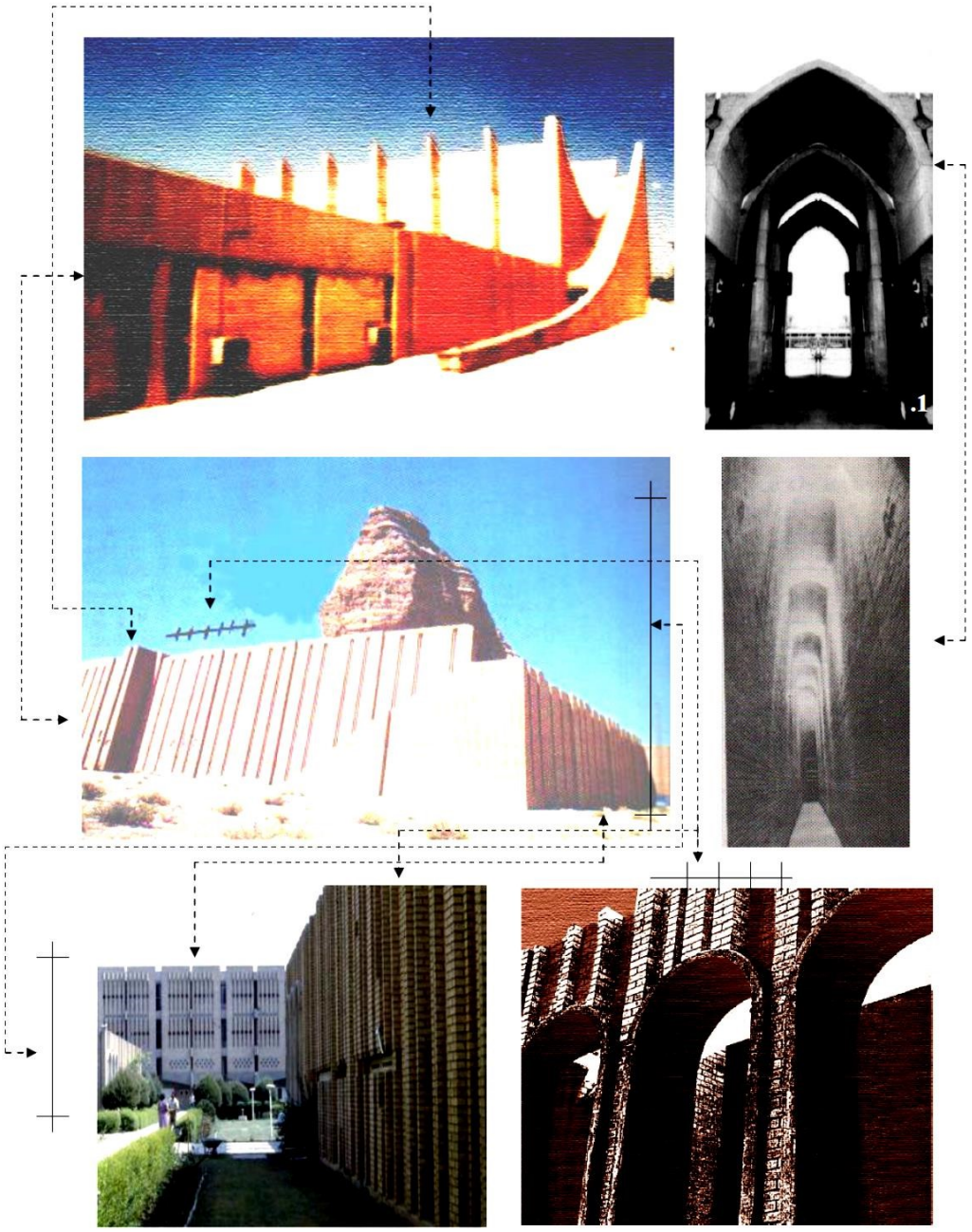


Figure 2.35: *Al-mustansria university\Baghdad, Qahtan Awni: the features inspiration between vernacular and contemporary*

The figure shows the inspiration from vernacular architecture features (zaqura and arches proportion) mixed with modern techniques

Source: *Researcher*

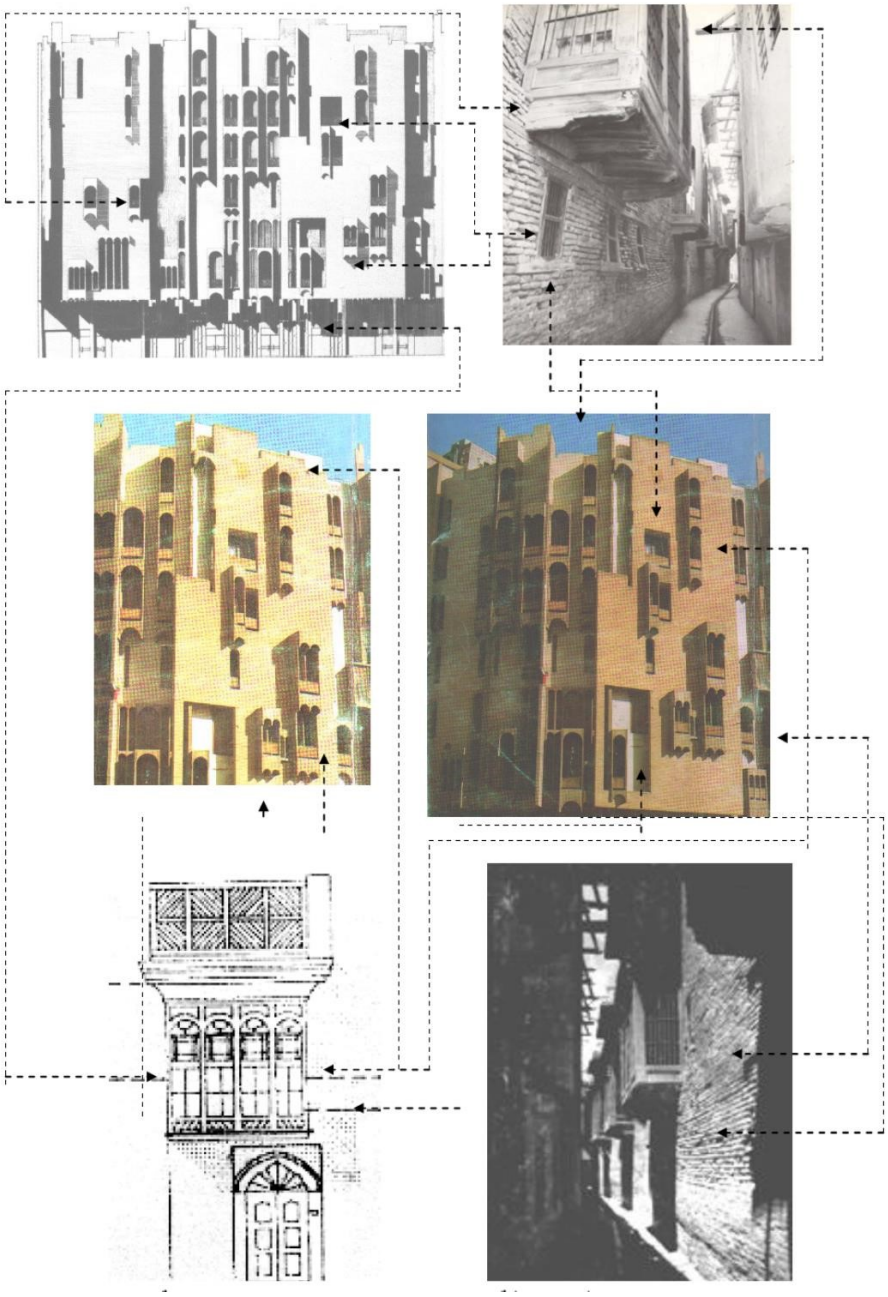


Figure 2.36: *Union of Industries building \ Baghdad, Rifat Chadirji: the features inspiration between vernacular and contemporary*

The figure categorizes the inspiration from vernacular house features(shanasheel) mixed with modern techniques

Source: *Researcher*

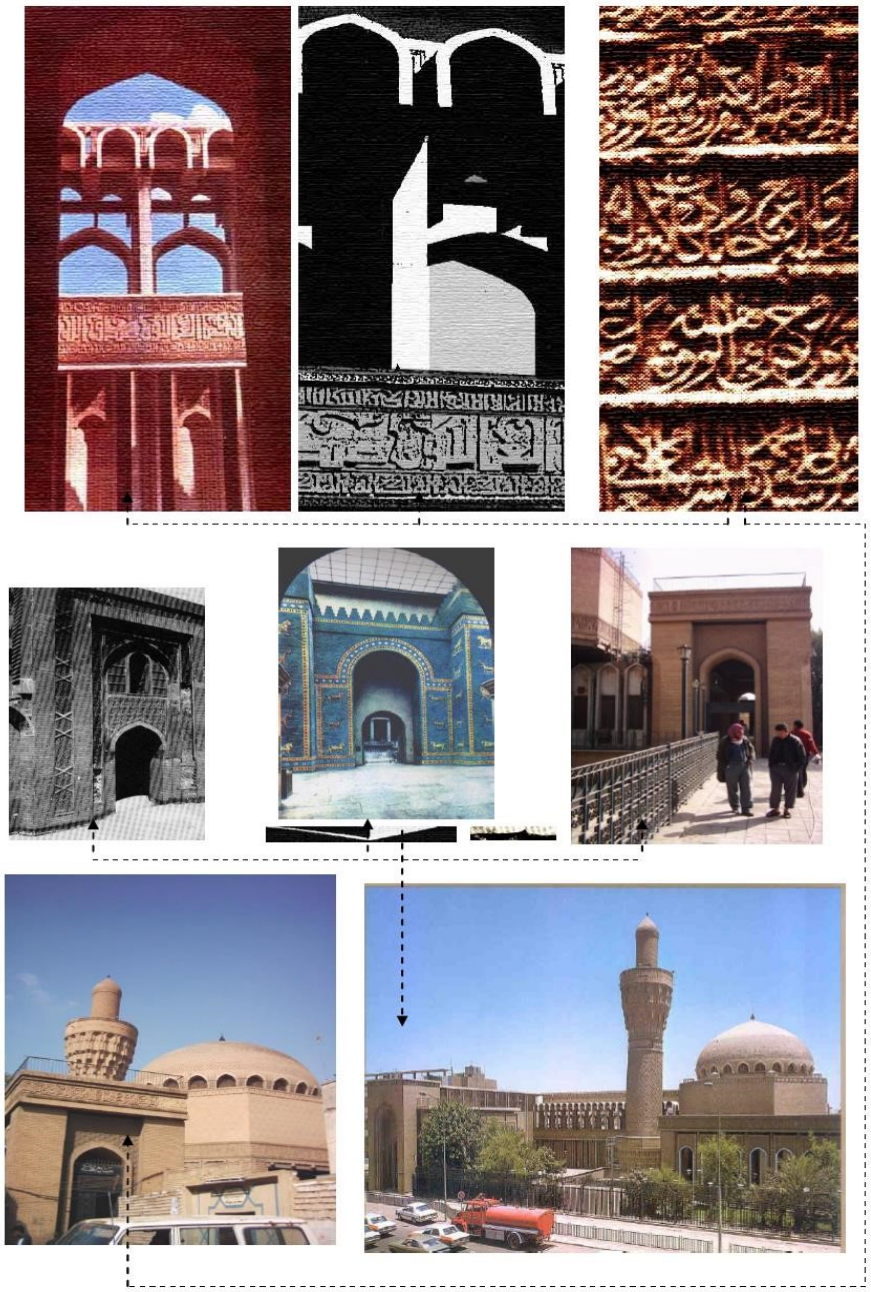


Figure 2.37: *Al- Khulafa Mosque\Baghdad, Mohamed Makiya: the features inspiration between vernacular and contemporary*

The figure categorizes the inspiration from vernacular architecture features(arches) mixed with modern techniques

Source: *Researcher*

Moreover, there are examples where the idea comes from vernacular elements when producing screen patterns. Such examples show that the traditional design remains but there is flexibility because the materials used are of concrete and brick but not wood which was traditionally used. The Iraqi architect Rifat Chadirji (1926) had knowledge of the classic model of the Iraq's vernacular architecture and used this as a framework for current needs. Chadirji`s Tobacco Building's architectural façade (1966) can be considered as an example in Baghdad and it is evident that contemporary architecture is used as well as his own ideas (Fig. 2.38). For example, Chadirji produced an illustrated shanashil image derived from brick and concrete instead of the pricy wood. Figures 2.38 illustrates aesthetic design quality through looks and technologies (Chadirji, 1986).



Figure 2.38: *Architect Rifat Al-Chadirji's Tobacco Building's façade elements in Baghdad, 1966 (Aalhashem,2008).*

Other examples that are visible in Baghdad as shown below highlight the main design taken from vernacular shanasheel but with blocks on buildings such as office blocks. A

number of architects were involved in this, namely Hisham Munir, (Figure 3.39) and Said Ali Madhlume, (Figure 2.40).



Figure 2.39: Union of Industries building in Baghdad design by architect Rifat AlChadirji in 1970 (Sherzad, 2002)



Figure 2.40: *Hisham Munir in 1965 designed the Ministry of Commerce in Baghdad*
Source: *Researcher (2012)*

Below is another example, using modern materials to create an extended first floor and not using material that was used in the past as seen in Al-Bataween, Baghdad, Figure 2.42. It confirms the change in house designs during the twentieth century as mentioned by (Al-Haidary, 2008; S. Al-Bayati, 2011; Nouri, 2014).

In addition, there are many examples of different types of buildings (commercial) that has a vernacular element with a modern twist and take texture of the screen pattern, colour and material into account, Figures (2.41, 2.42, and 2.44).



Figure 2.41: exemplifies Said Ali Madhlume's designed Art Institute in Baghdad in 1974 (Sherzad, 2002).



Figure 2.42: Baghdad's Al-Bataween area showing the transitional shanashil

Source: Alaulddin Aalhashem (2018)



Figure 2.43: shanashil idea used in a room in AL-Qasar Arasat Hotel (Baghdad 2019).



Figure 2.44: Inspiration of shanashil idea in house in Baghdad 2003. Image courtesy of Dr. Sahar Al- kaissi.

The following figures 2.45 and 2.46, categorize the inspiration from Vernacular Architecture mixed with modern techniques. The projects and design chooses of these Iraqis architecture is a good example of programmatically integrating vernacular features that have proven efficient over years into a modem and contemporary building programmer. In new houses, they are achieving low energy usage without additional construction costs. Electricity is very expensive and power generation is low therefore air conditioning option is not a good idea. The problems of vernacular features in Iraq are different from European countries, as mentioned by the relevant literature.



Figure 2.17: *Shanashil idea used in a room in home (Baghdad 2020) Image courtesy of Architecture Saad Fadhil*



Figure 2.18: *Inspiration of shanashil and courtyard ideas in house in Baghdad. Image courtesy of Dr. Sahar Al- kaissi.*

Research shows that most of the previous examples discussed is mainly the aesthetics aspect as being one aspect of the design element. Future construction needs to take climate change into account to keep an equilibrium of look and use of the building. Therefore, architects need to think about where the building should be built, the location of the sun and shade, the weather outside and how families would move around the buildings to name a few. One way of adopting this is to keep the traditional designs and change it according to modern times.

2.4.7 Understanding current approaches to possible architectural solutions

The period of the 1970s and early 1980s brought tremendous changes in the construction of houses in Iraq as yearly production of houses in Iraq crossed 50,000 units (Iraqi Ministry of Planning, 2010; Yousif, 2012). The main support obtained to housing production was from the revenue collected from oil industries (El Agraa and Ahmad, 1978; Meikle, 1992). The period of war and uncertainty in 1980 decreased the production of houses and this continued (UN-Habitat, 2003). Presently, the scarcity of houses in Iraq is due to a decrease in the amount of homes in Baghdad. In the country, there is about 6 million housing

shortage (Iraqi Ministry of Construction and Housing, 2019). This number corresponds to about one-quarter of the houses in the country (PADCO, 2006; Majdi, 2013; Iraqi Ministry of Construction and Housing, 2017). The condition of houses in Iraq clarifies that about 79% of houses have the real owners living in their properties (The World Bank, 201; Central Statistical Organization, 2014a, 2014b). An increased proportion of these residents reside in suitable circumstances. However, in the capital, Baghdad, studies have shown that nearly 190,000 houses, which correspond to about 31% of the city's overall houses, are not in an appropriate state (Dawood, 2017). In addition, such issues are resulting in an increase in the housing costs day by day, especially due to shortage in urban land and a decreased availability of useful structural material, which has further resulted in increased housing costs in the country (Iraqi Ministry of Construction and Housing, 2010; Majdi, 2013; Ali and Faiadh, 2014).

Due to the shortage of land and increased material costs, the construction prices of houses has increased from 49,600 Iraqi Dinar to 550,000 Iraqi Dinar, from 2002 to 2012 (Mohammed and Hamza, 2015). Presently, the cost of houses is very high, so it is almost impossible for people to purchase and afford houses in Iraq. It has been estimated by a study that the current poverty level of Iraq is about 22% (Al-Saady, 2013). The financial system has become ineffective and inefficient. The ratio of house cost to an annual salary is 6.75 (The World Bank, 2011). Due to such conditions, houses with inappropriate and unacceptable conditions are growing in the affected cities, especially in Baghdad. To elaborate, it has been estimated that over the period of six years, 24,000 houses were constructed, which were not formally constructed and were not appropriate for accommodating residents. In terms of formally constructed houses, only 22,000 houses were constructed which were deemed appropriate for accommodating residents (Dhabia et al., 2014). This comparison shows the growing increase in unacceptable homes in Baghdad and a decline in the standards of living. Moreover, this is not only the case in Baghdad but even in cities such as Hillah (Naser and Abaas, 2018) and Basra (Al-Othman et al., 2009), which are also found to be adopting similar trends as Baghdad.

These figures give some idea of the role that domestic buildings play in the built environment in Baghdad. Meanwhile, huge development projects are under construction

throughout the country but particularly in the capital; most of them consist of residential buildings which consume immense resources and produce great amounts of waste. All these buildings will put excessive pressure on the environment and its natural resources.

Incentivizing and implementing the retrofitting solutions mentioned in this study for designing houses across Baghdad will require complementary measures in place. Firstly, in order to encourage designers and owners to build their dwellings according to low energy design principles and requirements, policies would need to be developed and enforced.

The Iraqi housing policy was first released in 2010 in light of such events and was then renewed in 2017 by the government along with assistance from the UN. This approach was intended to overcome and reduce the complicated conditions of housing schemes. In the past, the only public sector was involved in the construction of houses but now with the inclusion of government, private sectors are invited to play a role as well in the construction of homes. The main initiative now is to construct houses to provide good opportunities to people and to develop newer solutions in view of the latest technology and architectural designs (Iraqi Ministry of Construction and Housing, 2010; 2017). The development in this field needs different options but assessment in such fields are restricted in terms of their scope. To elaborate, the present situation shows that a greater number of studies and research works are required to reach the level of complete examination. This study focuses on formulating the possible design strategies to conclude a solution for the country.

Future organization and enforcement of design policies are essential when low energy housing is adopted by Iraq's construction industries. To maintain the consumption of energy in the building industries (by using models), a funded institute needs to be created. Evidence shows the correct tools are being adopted for upcoming organization of policies and solutions to establish guidelines for implementing to create a clean, green and low energy generation of buildings. Guidelines have been provided on low energy domestic designs for sustainable homes, with support from professionals within the industry who design energy efficient homes in Iraq. The results from this study will positively support organizations in the upcoming years.

2.5 Summary

This chapter has detailed the results of several useful studies performed in various parts of the world including the hot climates of Iraq, Baghdad.

As shown in the first few sections of this chapter, the buildings sector could make a significant contribution to combating climate change while at the same time delivering various other social benefits. For the building sector, to act effectively into reducing a country's energy consumption, a building's energy efficiency strategies framework is required to ensure that the building requires less energy while achieving the desired function. The suitable policy, however, requires a good awareness of building performance status.

Even though the low-energy building status of the Middle East countries is different, there is a gap in knowledge and inadequate literature to cover the adoption of low-energy design in Iraq, Bagdad. This shows that this area needs further studies to evaluate the existing low energy design options in terms of building energy efficiency and comfort to provide guidance for future sustainable buildings. Furthermore, further research is needed to assess the support of society and industry for a paradigm shift to energy efficiency designs. Also, to establish a preference design strategy for a building's energy use based on the building area and the number of inhabitants that could be referred to when assessing energy consumption.

Moreover, the investigated and reviewed Baghdad's background from geographical, historical, climatic, and cultural perspectives, intended to clarify how these aspects affected housing. Peoples views in Baghdad have been affected because of the considerable political and economic changes, not to mention differing views relating to religious, social and cultural affairs especially post 2003. In addition, effecting psychological and behavioral aspects to follow the rules of the household. The people of Baghdad are open to modern values having been stripped of this in the past. The Baghdadi house is one of the remarkable changes in the physical and spatial arrangement. There is no clear link between vernacular and contemporary houses.

To summarize, the review of the literature has demonstrated the achievements of vernacular and contemporary housing typologies in Baghdad. Both of their typologies have varying benefits as well as features associated to their use in a particular dwelling. Thus, it can be clearly stated that any requirements which are not fulfilled by one typology are usually covered by the other typology.

Table 2.28 shows that both typologies houses have been achieved or probably to enable different levels of achievement of urban design, architectural, environmental, and socio-cultural factors.

Table 2.28: *Comparison of vernacular and contemporary houses for different factors*

strategies	**Vernacular house**	**Contemporary house**
Urban design factors	**Achieved**	**Not achieved**
Architectural factors	**Enable**	**Not Enabled due to detailed design concerns**
Environmental factors	**Achieved**	**Partly achieved**
socio-cultural factors	**Completely achieved**	**Not achieved**

Source: Researcher

The contemporary architecture of Iraq has been considered and has been found to rely significantly on mechanical services (particularly air conditioning) which is no longer sustainable. Contemporary homes have also been found to fail cultural requirements (e.g. privacy and community). They are not able to fulfil the requirements of the residents; hence, it is extremely important to understand how these needs may be met. Moreover, walkability and good socializing were found to be the positive results of the compact vernacular layout. However, in contemporary areas, the wide streets allowing cars and direct access to the house were found to be positive results satisfying different and more modern requirements.

In terms of environmental characteristics, the vernacular houses in Baghdad were responsive to the climate and the climate has had a strong influence on design of the homes. The integrated passive design strategies of vernacular houses, in comparison to the dependence on active systems found in contemporary houses, should, theoretically, contribute to lower running costs.

Furthermore, in terms of the sociocultural characteristics, the literature reviews showed that vernacular dwellings satisfy sociocultural requirements for the people by providing inhabitants with complete privacy. However, the design of contemporary homes does not satisfy the sociocultural requirements for the provision of complete privacy in terms of preventing overlooking by neighbours.

The review of the literature has demonstrated the achievements of vernacular and contemporary housing typologies in Baghdad. Both of their typologies have varying benefits as well as features associated with their use in a particular dwelling. Thus, it can be clearly stated that any requirements which are not fulfilled by one typology are usually covered by the other typology.

Chapter 3

Research Methodology

Chapter 3

3.1 Introduction

To achieve the aim of this research, several methods have been carried out.

> *Establishing a set of appropriate design approaches for informing future housing design in Iraq, which can enhance comfort levels with decreased energy usage along with cultural responsiveness. Therefore, this research considers the advantages of passive designs and vernacular courtyard houses for future architectural buildings in terms of both the local environment and cultural responsiveness.*

As previously stated, this research study is focused on identifying and evaluating the social and environmental performance of vernacular and contemporary residential units in Baghdad, Iraq. The main aim of the research is to set up suitable design strategies and provide insights into future design approaches in Iraq which improve thermal comfort, reduce energy consumption and include cultural responsiveness. To do this, the study will reflect on the acceptable aspects of vernacular courtyard houses for inclusion in future sustainable dwelling designs which are culturally responsive.

Academic and grey literature has been analysed to understand the gap in the field of study and develop awareness of the problem. A synthesis of the literature is provided in Chapter 2.

This chapter presents the research methodology used to gather and evaluate data to further support academic and grey literature, while also addressing objectives 1-4.

This range of objectives requires multiple methodological approaches including quantitative and qualitative methods.

Such a mixed methods approach gives an opportunity for the discovery of newer insights into ethnic and social phenomena.

According to Saunders and Tosey (2012), this methodology has a range of benefits. They indicate that popular research strategies under the category of qualitative and quantitative research can be grouped as below:

Mono Method: This method involves using a single data gathering and evaluation technique that uses either a quantitative or a qualitative methodology. There are assertions that this method can result in a construct validity issue because prejudice can develop from using a single method assessment.

Multiple Method: This method includes the utilization of multiple quantitative or qualitative techniques to investigate and inspect a specific topic or trend. This method offers proof and verifies the discoveries that will create a level of precision in the study. The key quality of the multiple method procedure is the creation of several data types that offers extensive insight into the discoveries.

Mixed Method: The mixed method is also referred to as the hybrid procedure and involves the use of several techniques that incorporates data gathering and evaluation as well as qualitative and quantitative procedures. Within the last decade, this is a method that is broadly acknowledged and focuses on maximizing the use of several methodologies to investigate various research challenges.

As stated above, this study uses a mixed methods approach to establish sets of design strategies for new housing units in Baghdad, as a case study. This involves different theoretical and empirical investigations. A combination of bioclimatic analysis, and analysis of questionnaires with mainly quantitative responses and qualitative interview responses were carried out to provide better and naturally welcoming housing solutions that are able to satisfy functional expectations as well as social needs.

Below are the four important stages that make up the structure of the study to establish sets of design strategies. Table 3.1 and Figure 3.1 summarize the research stages.

- ***Stage 1:*** Identifying and analysing of climatic strategies which have an influence on reducing the consumption of energy along with taking into consideration the plausible solutions for construction attained at active and passive levels. This will be addressed in chapter four;
- ***Stage 2:*** Examining levels of householders' (public) satisfaction with both contemporary and vernacular houses with regards to environmental and cultural performance. This will be addressed in chapter five;
- ***Stage 3:*** Engaging with professionals and understanding their ideas on designs and construction in terms of passive designs of modern housing units in Baghdad, for

example academic, government and private sector. This will be addressed in chapter six.

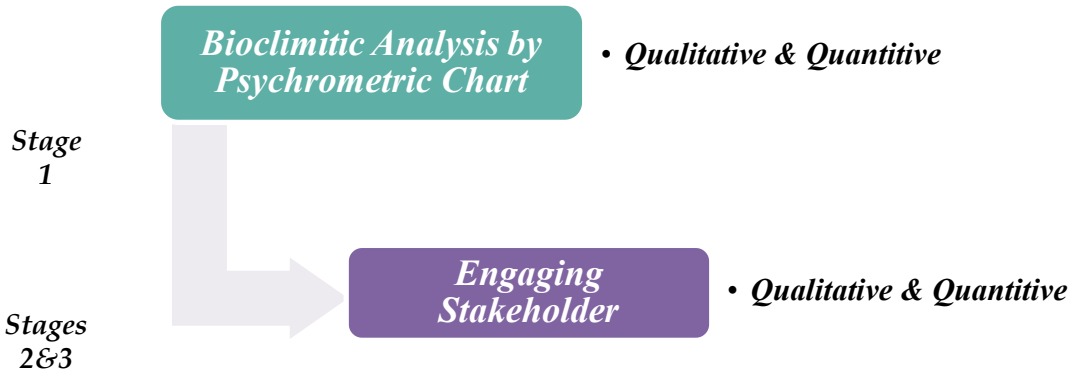


Figure 3.1: *Methods used in the research*

Table 3.1: *Methods used in the research*

Aim of the research	*Establishing a set of appropriate design approaches for informing future housing design in Iraq, which can enhance comfort levels with decreased energy usage along with cultural responsiveness. Therefore, this research considers the advantages of passive designs and vernacular courtyard houses for future architectural buildings in terms of both the local environment and cultural responsiveness.*		
Stage 1 *Bioclimatic analysis*	**Objective 1**	*Identify and analyse feasible passive strategies for application in Baghdadi climate;*	**Chapter 4** *Bioclimatic Analysis*
Stage 2 *Public survey*	**Objective 2**	*Examine the levels of householders' (public) satisfaction with both, contemporary and vernacular houses with regards to their environmental (comfort and energy) and cultural performance;*	**Chapter 5 & Chapter 6** *Engaging Stakeholder*
Stage 3 *Expert Consultations*	**Objective 3**	*Explore the perceptions of built environment professionals relating to design and construction of modern housing units and their incorporation of passive strategies in Baghdad;*	
Stage 4 *Synthesis the findings from stages 1,2,3, and 4*	**Objective 4**	*Achieving the aim of the research*	**Chapter 7** *Discussion: Design Strategies for Future House in Baghdad*

3.2 Description of Methodological Approaches

Four key methodological approaches were adopted to meet the six objectives described in Section 3.1: literature review; bioclimatic analysis using a psychrometric chart; public perception survey; and Experts perception survey

Table 3.1 and Figure 3.1 summarize the research stages. These stages will be described fully in the following subsections:

3.2.1. Stage One: Bioclimatic Analysis Using Psychrometric Chart for Baghdad

To achieve **objective 1** of this research, this method has been carried out.

A bioclimatic analysis for Baghdad was carried out using a psychrometric chart to identify climate appropriate passive designs for potential inclusion in the sustainable designs. This is an established research method which has been used for this purpose in several investigations (e.g. Szokolay, 1986; Givoni, 1992; Ajibola, 2001; Lam et al., 2006; Milne et al., 2009; Tahbaz, 2011; Mahmoud, 2011; Shallcross, 2012; Al-Azri, Zurigat, and Al-Rawahi, 2013; Olgyay, V., 2015; Khambadkone and Jain, 2017).
The important step involved the construction of weather simulation files (EPW). The Meteonorm program was used as a tool to create the EPW files (www.meteonorm.com). Weather data for Baghdad was obtained from WMO Weather station. It applied 33.33° N latitude and 44.43° E longitude. This study used the time period 2000 to 2009 which was closer to the real data from Baghdad airport meteorological stations (1997-2008) (see Figs. 3.2 and 3.3). In addition, this period is more appropriate for bioclimatic analysis as it takes extreme warm and cold days into account.

Temperature and RH data for the weather station location was visualized on a psychrometric chart using Climate Consultant Version 6.0. This software incorporates four comfort models: ASHRAE Standard 55-2005, ASHRAE Fundamentals, California Energy Code 2013 and comfort model in ASHRAE Standard 55-2010 (Fig. 3.4).

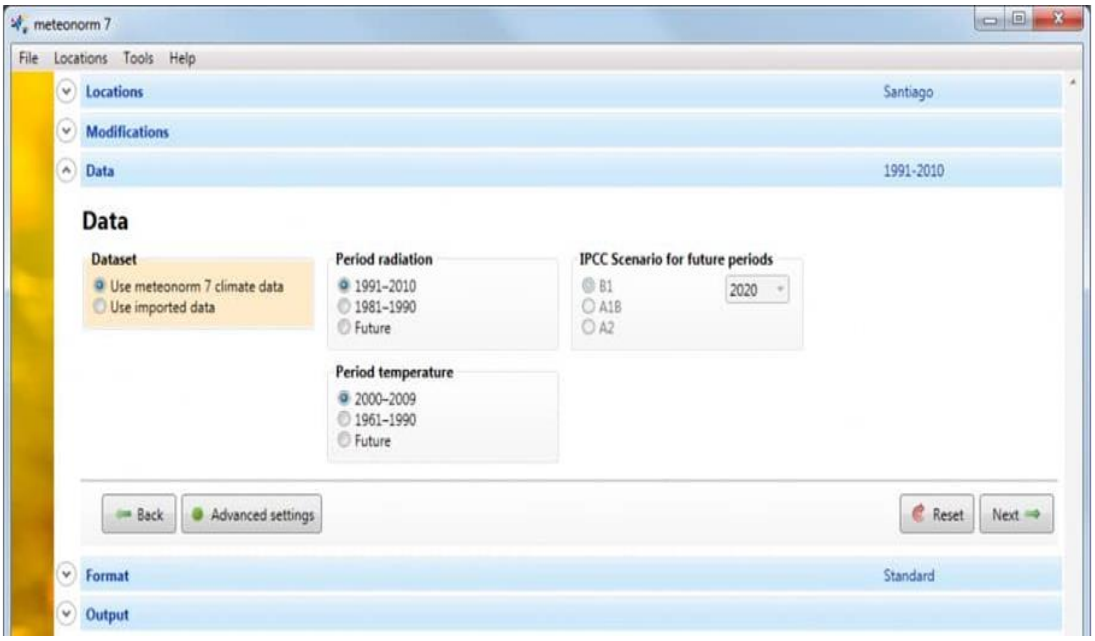


Figure 3.2: *Screenshot from Meteonorm program*

WEATHER DATA SUMMARY

LOCATION: BAGHDAD, IZ, -
Latitude/Longitude: 33.33° North, 44.43° East, **Time Zone from Greenwich** 3
Data Source: MN6 192 WMO Station Number, **Elevation** 108 ft

MONTHLY MEANS	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	
Global Horiz Radiation (Avg Hourly)	82	104	120	134	147	152	152	149	136	103	94	74	Btu/sq.ft
Direct Normal Radiation (Avg Hourly)	97	102	94	93	105	111	110	109	109	82	104	82	Btu/sq.ft
Diffuse Radiation (Avg Hourly)	38	49	62	69	69	71	70	70	64	55	43	38	Btu/sq.ft
Global Horiz Radiation (Max Hourly)	196	227	277	287	296	297	306	291	285	247	206	180	Btu/sq.ft
Direct Normal Radiation (Max Hourly)	278	272	258	257	237	212	235	219	250	245	271	276	Btu/sq.ft
Diffuse Radiation (Max Hourly)	101	117	130	150	157	146	160	153	132	125	94	94	Btu/sq.ft
Global Horiz Radiation (Avg Daily Total)	832	1123	1426	1729	2024	2162	2124	1968	1660	1150	968	727	Btu/sq.ft
Direct Normal Radiation (Avg Daily Total)	978	1107	1122	1203	1457	1578	1544	1447	1330	918	1072	809	Btu/sq.ft
Diffuse Radiation (Avg Daily Total)	390	535	743	897	949	1006	982	927	793	617	450	373	Btu/sq.ft
Global Horiz Illumination (Avg Hourly)	26	32	38	42	46	48	48	47	43	33	29	23	footcandles
Direct Normal Illumination (Avg Hourly)	25	27	24	24	27	28	28	28	28	21	26	21	footcandles
Dry Bulb Temperature (Avg Monthly)	45	47	55	64	75	82	88	87	79	70	56	48	degrees F
Dew Point Temperature (Avg Monthly)	37	35	38	43	45	47	51	53	48	44	40	40	degrees F
Relative Humidity (Avg Monthly)	75	65	55	48	37	32	31	34	36	44	58	73	percent
Wind Direction (Monthly Mode)	70	210	210	210	200	240	210	260	240	200	110	120	degrees
Wind Speed (Avg Monthly)	5	5	6	6	6	6	6	6	5	4	4	4	mph
Ground Temperature (Avg Monthly of 1 Depths)	60	56	55	56	60	66	72	77	78	77	72	66	degrees F

Back Next

Figure 3.3: *Screenshot from Climate Consultant: Weather data for Baghdad 6.0*

This stage involved an analysis and discussion of the boundaries of passive strategies on the psychometric chart by analyzing the data that was developed based on weather simulation files (EPW) (www.meteonorm.com) for Baghdad in the Metronome database. Then, the researcher used Climate Consultant (version 6.0) (https://climate-consultant.informer.com/6.0/) in order to present the new files graphically, which assisted this study in creating more effective low energy buildings. This tool is known to perform well and is an adequate technique for investigating an approach for building designs that can be associated with climatic conditions.

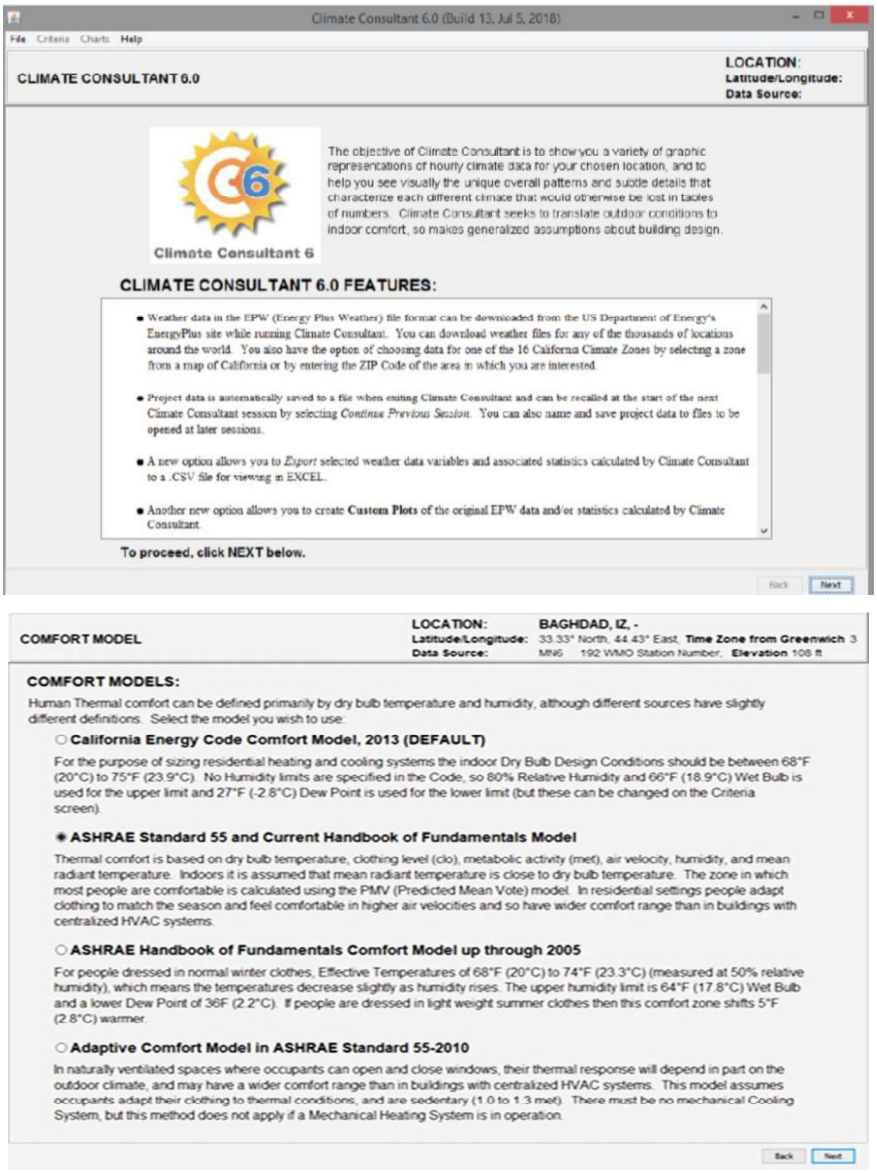


Figure 3.4: *Screenshots for Climate Consultant 6.0*

As can be seen from Figure 3.5, the building's comfort zone can be analyzed by locating and examining the following parameters;

- ***Dry bulb temperature:*** The lines that are drawn straight within the psychrometric chart are not always parallel to each other. These lines are usually inclined slightly from the vertical position on the chart. This is basically the *t*-axis or, in other words, the abscissa (horizontal) axis. Each of this line is used to represents the constant temperature.

- ***Dew point temperature:*** The line that is located at the state point and follows the horizontal line of the constant humidity ratio to the intercept of 100% RH. It is also known as the saturation curve. This basically represents the dew point temperature that is equal to the fully saturated dry bulb or wet bulb temperatures.

- ***Wet bulb temperature:*** The lines that are oblique and are quite different from the enthalpy lines. These lines are usually identical to the straight ones, but these are not exactly parallel to each other. Thus, the lines that intersect the saturation curve at the DBT point define the wet bulb temperature.

- ***Relative humidity:*** The relative humidity is represented by the hyperbolic lines that can be shown in intervals of 10%. Usually, the saturation curve is at 100% RH, although the dry air is at 0% RH.

- ***Humidity ratio:*** The lines that are horizontal on the chart represents the humidity ratio. The humidity ratio is basically used to express the mass of moisture per mass of dry air (pounds or kilograms of moisture per pound or kilogram of dry air). The range of the humidity ratio is from 0 for dry air up to 0.03 (lbmw/lbma) on the right hand ω-axis, the ordinate or vertical axis of the chart.

In Figure (3.6), it can be seen that various boxes are drawn to define the zones. The dark blue boxes are usually used to represent the comfort zone of the building occupants, while the other colors are used to represent the design strategies that are essentially required to study. This is because it enables the comfort zone within the building to be potentially expanded. This stage will be analysed in chapter four of this research.

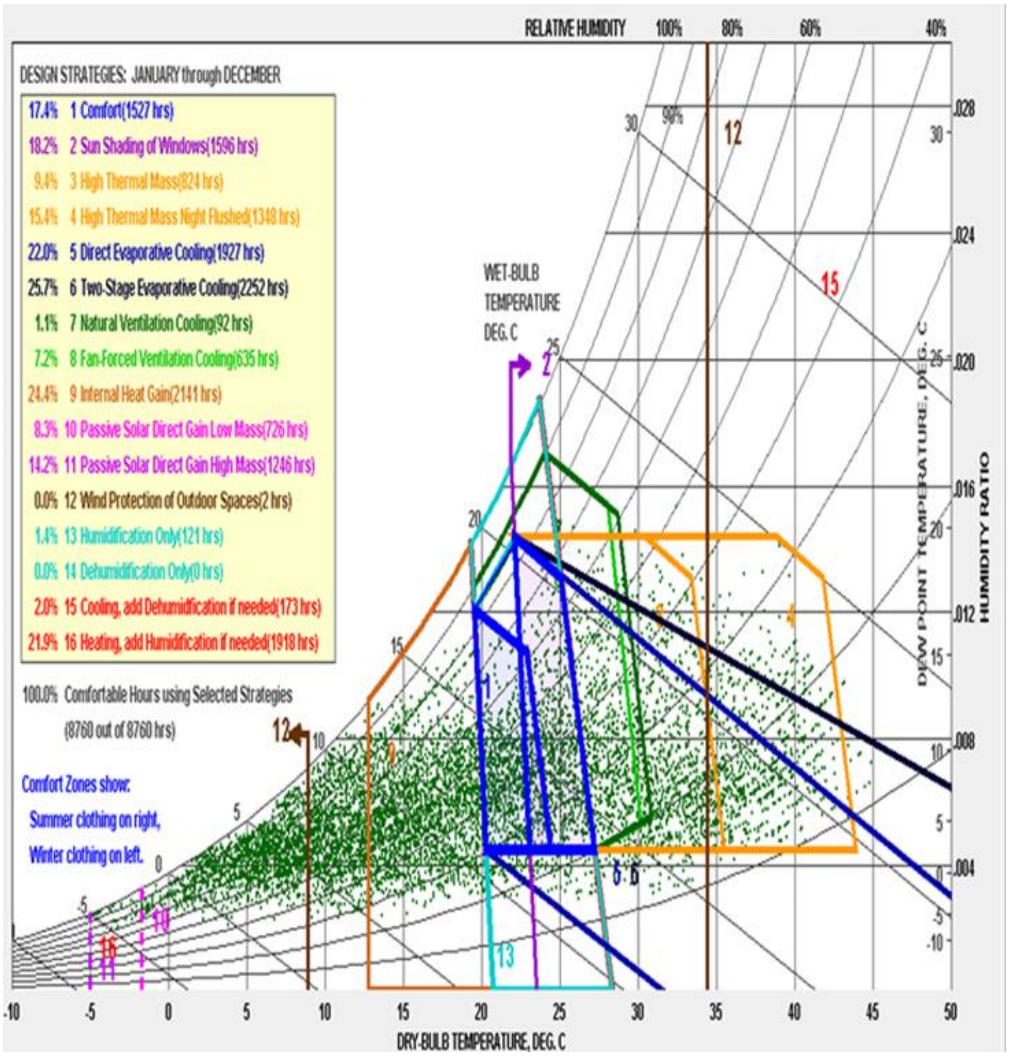


Figure 3.6: *Psychrometric Chart for Baghdad zone: Strategies boundaries chart and the ASHRAE comfort zone.*

3.2.2 Stage Two: Public Survey Analysis and Perception on Low-energy Homes

Assessing occupants' perceptions regarding their dwelling in terms of thermal comfort in different seasons was important in order to satisfy the needs and requirements of individuals in Baghdad, Iraq. In addition, socio-cultural responsiveness is an important feature for informing the solution development for current issues in houses. Thus, in this section, objective 5 will be accomplished through a combination of surveys developed and provided to the occupants in vernacular and contemporary houses.

This stage presents an investigation into the public perception of low-energy homes. The respondents of this stage are all from Baghdad city and were currently residing in the city during the course of this investigative study. The obtained responses were analysed using Microsoft Excel software. This stage will be analysed in chapter five of this research. Appendix A also contains the full questionnaire in English.

The questionnaire reached 112 participants, 98 of whom (87.5%) were interviewed and completed it successfully. Major restrictions were encountered when selecting the participant samples for the research which was viewed as significant. This is mostly due to security restrictions in Baghdad which limit freedom of movement around the city. This limited the number of participants for the survey. Another restriction was related to several religious ceremonies held in the country. As a result, the distribution of the questionnaires was subject to security provisions and there was no easy access during this period of time. The survey was therefore predicted to produce better results in a public club (Iraqi Hunting Club) and shopping mall to ensure that the researcher was also secure.

Permission was given to the researcher from security agencies (Ministry Interior of Iraq and local security agency to the mall/club) to perform the survey. The security office provided one member of staff to ensure the personal safety of the researcher.

The respondents (98/98) agreed and were happy to answer the research questionnaires about their houses. The replies and answers of the candidate provide useful insights. However, presenting the questions in Arabic initially posed a challenge.

The survey took into account the different experiences to build on top of existing literature in order to provide a modern applicable understanding of these different types of houses in existing weather conditions along with the social and cultural differences. The questionnaires obtained in Arabic were translated into English conducted urging a fieldwork study in Baghdad in July/August 2016. The full questionnaire has been reproduced in Appendix A in English.

This section of the research study evaluates the outcomes generated from the questionnaire that was developed from both vernacular and contemporary houses using the sections listed below:

I. Part A: Demographic information for the respondents' answers from both houses are presented together;

II. Part B: Local domestic stock typology and current problems;
III. Part C: Patterns of energy consumption and rates of energy use fulfilment;
IV. Part D: Public perception and knowledge about vernacular design via contemporary design
V. Part E: Public perception and knowledge of energy-efficient housing;
VI. Part F: Public knowledge of energy retrofitting and sustainable energy homes,
VII. Part G: Cultural barriers in the delivery of low-energy homes.

- **Part A: Demographic Information**

The demographic details from the answers of the respondents from both houses are both presented and evaluated in this section of the research study.

The participants were divided into five age categories and four main groups of education levels. Variety in the ages and education level of the respondents was sought in order to elicit a range of viewpoints as to how they see their houses.

Question Intention	Question	
Gender and age of the respondents	**Gender?**	Male
		Female
	Age?	From 18-24
		From 25-34
		From 35-49
		From 50-60
		More than 60
Academic education level	**What is your highest qualification?**	Diploma
		Bachelor's Degree
		Master Degree
		Ph.D. Degree
Number of occupants within a family	**How many occupants are there in your home?**	1-2
		3-4
		5-8
		More than 9
Respondents period of occupation of their houses	**How long have you lived in your current home?**	less than 5 years
		5-10 years
		11-20 years
		More than 20years

- **Part B: Local Domestic Stock Typology and Current Problems;**

This section was intended to provide additional insights into the respondent's residential situation, covering tenure, dwelling type, dwelling space and the respondent's experience of the property (occupation time and satisfaction).

Question Intention	Question	
Type of tenure	**Are you the….. of your home?**	Owner
		Tenants
		Living with family
		Other (provide details)
The dwelling type	**What type of dwelling do you live in?**	House
		Flat
Size floor areas of the dwellings	**What is the floor area of your home?**	Less than 100 m²
		100-200 m²
		201-300 m²
		More than 300 m²
The level of fulfilment with the residence presently occupied by the participants	**How satisfied are you with your home (in terms of meeting your households needs in the summer)?**	Very satisfied
		Fairly satisfied
		Neither satisfied nor dissatisfied
		Fairly dissatisfied
		Very dissatisfied

- **Part C: Patterns of Energy Consumption and Rates of Energy Use Fulfilment**

Certain key factors were gathered regarding the unusually high energy consumption rates in the residential sectors of Baghdad by conducting a thorough in-depth analysis in literature reviews. The energy consumption patterns and the understanding of the public is evaluated. The factors are identified by presenting a series of questions that will analyze the reason behind increasing consumption of energy in the housing sectors of Baghdad.

Question Intention	Question	
The average hours per day of occupancy	**How long is your house occupied per day on average (not including sleeping hours)?**	Less or equal than 3 hours/day
		4-6 hours/day
		6-10 hours/day
		Greater than 10 hours/day
Using air-conditioning	**Is it important to use air conditioning in your house?**	Yes
		No
	Which areas of the house are supported by the air conditioning?	In all rooms
		In the majority rooms
		In some rooms
	How often do you use the air-conditioning?	All the year
		All summer time
		When the temperature is very high
		When the temperature is very low
	D: How many hours per day is the air conditioner used during summer times?	Less than 5 hours per day
		5-10
		10-15
		15-20
		Over 20 hours per day
Respondents' actions during high temperatures and power outage	**If electricity is off what will you do to escape a high temperature?**	Open windows to get cross ventilation
		visit a family whose air conditioning is working
		Sit in the garden
		Go to do shopping
		Others (please specify)

- **Part D: Public Perception and Knowledge about Vernacular Design via Contemporary Design**

This section seeks the respondents' opinion on the most important aspects of vernacular design and what can be considered as barriers to their applications.

Question Intention	Question	
Opinion on vernacular design and its suitability with current requirements	How would you describe the vernacular Iraqi design? What are its key features?	Please write your answer below
Proportion of respondents wishing to have courtyards in current and future houses	Assuming there were no practical or financial barriers, would you like to include vernacular features (such as courtyard..etc.) or techniques in your current or future house?	Yes, go to next Q
		No
Primary motive for adding vernacular features (such as courtyard)	What would be your primary motive for adding vernacular design elements if you answered yes to Q above?	Expresses culture/identity
		Environmental aspects
		Aesthetic qualities
		Other
		None
Desirable abilities of courtyards	What are the most valued as well as appealing qualities that you associate with the vernacular design features (such as courtyard).	Privacy
		Its form and shape
		Tranquillity, quiet, calm and relaxation
		Spaciousness, openness to the sky
		Protection and security from streets
		Use of green spaces, plants, shrubs, trees, and so on.
		Cooling and natural ventilation
		Natural sunlight in the houses
		Social space and stronger family ties
		Identity, self-expression
		Others, please indicate:
Barriers and limitations experienced by residents in adopting courtyards	How would you agree or disagree with the following issues that would limit you from implementing a courtyard in your current or future dwellings?	Having a small plot of land
		It reminds you of vernacular houses
		Cultural changes from Iraqi's transformation
		Lack of government regulation to promote courtyards
		High real-estate prices
		Scarcity of residential Land
		Iraqi's housing crisis
Preferred types of houses	What kind of houses do you prefer to live in? Why?	Vernacular houses
		Contemporary houses
		Contemporary houses with vernacular style
		new houses which combined (vernacular+ Contemporary+ technology)

- **Part E: Public Information and Knowledge of Highly Efficient Modern Homes**

This section investigates the knowledge of the respondents on low-energy homes.

Question Intention	Question	
sustainable, low energy house	A: Do you understand the concepts of sustainable, low energy or green building?	Please tick the appropriate box
		Yes, Go to question B and C
		No
		I don't know
	B: If yes (A), please indicate the sources of your understanding?	Internet
		Media
		News
		TV
		Experiences
		Advertising
		Others
	C: If your answer (A) is yes, do you think that houses that incorporate these features are more expensive than other houses?	More expensive
		Less expensive
		Please explain your answer below
Adoption of sustainable, low energy house	Do you agree or disagree that Iraqi buildings need to adopt more energy efficient designs that would save energy and reduce CO2 emissions.	Yes
		No
Beneficial of sustainable, low energy house	What do you think about reducing carbon footprint when it comes to domestic buildings?	good for me/my family
		good for the nation middle east
		good for the world
		Neutral
		No benefit

- **Part F: Public Acceptance in Terms of Sustainable as well as Energy Retrofitting, Low-energy Houses**

This section seeks the respondent's opinion on the extent to which design considerations for retrofitting homes for sustainable and energy-efficient homes are approved by the public.

Question Intention	Question		
Respondents' opinions on the future house	In our opinion what do you think that new houses must achieve?	Comfort	
		Beauty	
		Economic	
		Safety	
		All of the prior reasons	
		Others (please specify)	
Respondents' opinions on the potential of certain actions to save energy in future homes	Do you agree or disagree with the following methods would contribute to saving energy and increase sustainability?	energy Reduce consumption	install solar electricity generation system, i.e. photovoltaic, (PV), in order to reduce consumption from the national electricity grid supply
			use solar radiations for water heating to save energy
			install shading devices around windows in order to save energy consumption
			Replace single glazing with an efficient double or triple glazing minimizes heat losses\heat gain.
			Install a grey water recycling system for irrigation purposes.
		Shortage of information on products	Give the people awareness of low carbon energy buildings
			There are shortages of sustainable products such as PV on the Iraqi market
			The government should regulate the market and establishments to promote sustainable buildings
Respondents' opinions on the future plans of residential buildings	In designing future dwellings how important are each of the following factors to reduce energy (Please tick the appropriate box).		Future dwellings in Iraq\Baghdad must be designed to save energy consumption
			The future dwellings in Iraq\Baghdad must be designed according to sustainable, low energy criteria established as compulsory by the government
			The government should take serious action and steps to introduce rules to adopt low energy building in Iraq

- **Part G: Social Barriers in the Use of Low-energy Homes**

This section presents the respondents' opinion on some of the hindrances, known as social barriers, that can affect the increase or decline of energy efficiency and using sustainable principles in Baghdad.

		1.Strongly agree	2. Agree	3. Neutral	4. Disagree	5. Strongly disagree
Please indicate your point of view on the following socio-cultural issues	Is the size of someone's house a symbol of the person's status in society?					
	Would you agree to live in a smaller house in order to reduce energy demands?					
	I socialize with my neighbors					
	Would you agree to have only one guest room for both genders?					
	Would you agree to have bedroom appropriately sized to fit the needs of occupant?					
	Would you agree with using a private garden for social gathering?					
	Would you agree for using roof for sleeping purpose?					

3.2.2.1 Sample

A total of 98 respondents participated in the survey: 12 of them represented vernacular residents, while the remainder were contemporary residents. The researcher acknowledges the low proportion of candidates represented vernacular houses due to the fact that many vernacular houses and neighborhoods lost their original residents, and today vernacular houses were sub-divided for multiple occupies by poorer households, as evidenced in literature review and personal observation. These respondents represented both genders and a range of ages which is similar to that found in the Baghdad public – although is not claimed as statistically representative.

The main aim and objectives of the survey were described to the respondents. They were informed that the significance of the survey was to achieve convenience and fulfillment of the residents and the thermal performance of their houses. Additionally, they were told that the analysis of the findings of the survey would be significant in establishing design strategies and providing insights into future houses and developing solutions towards housing problems. They were also informed that the objective of the survey was to

establish an assessment between the inner thermal conditions of both vernacular and contemporary residential units.

The questions of the survey were designed, developed and dispersed to the general public according to various educational backgrounds and age groups.

The gender division from the survey in the contemporary house section was 48% males (41/86) and 52% females (45/86,) while for the vernacular house section, it was 75% male (9/12) and 25% females (3/12).

The volunteers were categorized by age. 75% (74/98) of the volunteers were aged between 25 to 49 years from both genders. 12% (12/98) of the age group fell between 50 to 60 years, 8% (8/98) were over 60 years and 4%, which represented the smallest age category, were less than 24 years old. Although there was not an even split across the age categories, all age categories were represented.

Every participant voluntarily indicated their age. On this basis, they were categorized into 51% males (50/98) and 49% females (48/98). The highest number of respondents were males.

3.2.2.2 Sampling Techniques

A survey distribution procedure using manual printed questionnaires was employed in the research. Although this is slower and more expensive in comparison with an online survey (Stanton, 1998; Weible and Wallace, 1998). it generates a more comprehensive response from individuals. The procedure was undertaken in Baghdad between July 2016 and August 2016. This was carried out directly by picking random participants with different genders, ages and academic status in various areas within Baghdad in order to discover their connection and distinctions socially.

The survey was facilitated by face-to-face interviews; the questionnaire was distributed by hand to individuals in Baghdad. The generated responses from the survey and the outcomes were evaluated by the researcher.

3.2.1.3 Ethical Considerations

An ethics approval form was submitted to the Welsh School of Architecture/Cardiff University and approved. All respondents completed a consent form, which explained the purpose of the survey and assured them that their data would be held confidentially.

3.2.3 Stage Three: Expert Consultations for Setting Design Techniques for Future Homes in Baghdad

objective sex will be achieved in this section by incorporating a series of professional insights for designing new housing in Baghdad using a combination of questionnaires and analysis of the responses. The main objective of this assessment is to obtain professional judgments on low-energy strategies and design techniques for setting up design strategies that will assist designers, architects and engineer in designing energy-efficient home considering Baghdad's climatic condition and culture.

The researcher reached 61 participants, 48 of whom (78.6%) were interviewed and successfully completed the questions in this survey and fully worked with the investigator along with offering innovative solutions and responses. Table 3.2 contains the background of the interviewees. This stage has been analysed in chapter six of this research. Appendix A also contains the full questionnaire in English.

The survey can be considered in the following parts:

I. Part 1: Demographic Information;
II. Part 2: Opinions on design and construction relating to bioclimatic design of contemporary housing for Baghdad;
III. Part 3: Opinions on efficient solutions to reduce energy demand of houses;
IV. Part 4: Perception of cultural barriers in the delivery of low energy homes.

This stage contains five phases of consultations with the professionals. There were various criteria of design techniques involved in these consultations when designing energy-efficient homes in Baghdad.

The analysis will be presented under these four phases (see chapter six for more details).

- **Part A: Demographic Information**

The demographic details from the answers of the respondents were presented and evaluated in this section of the research study.

The participants were divided into four age categories and two main groups of education levels. Variety in the ages and education level of the respondents was sought in order to elicit a range of viewpoints towards architecture and housing conditions.

Question Intention	Question	
Gender and age of the respondents	Gender?	Male
		Female
	Age?	From 30-39
		From 40-49
		From 50-60
		More than 60
Academic education level	What is your highest qualification?	Master Degree
		Ph.D. Degree

- **Part 2: Opinions on Design and Construction Relating to Bioclimatic Design of Contemporary Housing for Baghdad**

This section investigates the respondents' opinions on design and construction relating to the bioclimatic design of contemporary housing for Baghdad. A mixture of open-ended and closed-ended questions were used to solicit information and ideas from the experts' own knowledge, experience and understanding of the topic. The same question was answered by all 48 participants in order to make accurate comparisons in the data analysis phase.

Question Intention	Question
Issues facing Baghdadis domestic built environments	In your perception, are there any issues with contemporary house in Iraq? If yes, could you provide any solutions to these issues?
Apply vernacular features in contemporary or future dwellings	Do you think vernacular features should be used in the present or future Baghdadis dwellings? Why? What are the features?
Specific aspects in participants' home	Which of the following factors do you aspire to have significance in your house: Culture, Identity, Modernity, Environment sustainability or any others? Rank them, please.
Issues prevent from adding a vernacular element	Do you believe there are issues that may prevent from adding a vernacular element in current or future house?
Designing a special architectural model with specifications appropriate to the particular region and climate	Do you think there are possibilities of designing a model that can use as a reference to help architectures when designing in the same circumstances?

- **Part 3: Opinions on Efficient Solutions to Reduce Energy Demand of Houses**

This section explored the expert's opinions on proposed solutions to reduce energy demand in domestic buildings (See chapter six for more information).

In this phase, two rounds were used to gain consensus from the panel. In round one and two, a range of response options were used. These included the Likert scale from one to five (where one is considered to be "not important" and five "very important") which was used to represent ranking.

Round one: The first round was designed to score items with a view of reaching consensus. The chosen group (48) were asked to give their opinions on the strategies that were mentioned in the literature. Typically, a Likert scale represents the ranking or ratings (or both). The group were only invited to the second round if consensus was not accomplished in the first round.

Round two: The second round was based on the results of round one, where the experts were asked to give their views and suggestions for any further options from the first round.

Closed-ended questions were used to solicit information and ideas from the experts' own knowledge, experience and understanding of the topic. The same question was answered by all 48 participants in order to make accurate comparisons in the data analysis phase.

- **Part 4: Perception of ccultural barriers in the delivery of low energy homes.**

This section explored the expert's perception of cultural barriers to the delivery of low energy houses (See chapter 6 for more information's).

In this phase, two rounds were used to gain consensus from the panel. In round one and two, a range of response options were used. These included the Likert scale from one to five (where one is considered to be "not important" and five "very important") which was used to represent ranking.

Round one: The first round was designed to score items with a view of reaching consensus. The chosen group (48) were asked to give their opinions on the strategies that were mentioned in the literature. Typically, a Likert scale represents the ranking or ratings (or both). The group were only invited to the second round if consensus was not accomplished in the first round.

Round two: The second round was based on the results of round one, where the experts were asked to give their views and suggestions for any further options from the first round.

Closed-ended questions were used to solicit information and ideas from the experts' own knowledge, experience and understanding of the topic. The same question was answered by all 48 participants in order to make accurate comparisons in the data analysis phase.

3.2.3.1 Sample

A total of 48 respondents participated in the survey. The main aim and objectives of the survey were described to all respondents. They were informed that the significance of the survey was to capture the perceptions of relevant professionals on the feasibility of incorporating passive design strategies into a new low-energy design concept for Baghdadi dwellings. This feasibility was intended to consider not only the technical feasibility, but social and cultural aspects which may be a potential barrier to implementation (as analyzed in chapter six).

This stage presents a synthesis of the insights from professionals on the potential design of new residential homes in Baghdad elicited from a combination of questionnaires and interviews (face-to-face interviews). It is important to take experts' views on board in relation to the building of homes in the past and present. This is because it gives an understanding of the challenges the country faces in creating a modern Baghdad, but it also gives the opportunity to look at how to design energy-efficient home considering Baghdad's climatic condition and culture.

The questions of the survey were designed, developed and dispersed to the expert panel according to various educational background and age groups.

All of the participants (48) stated their gender, based on which they were split into 73% (35/48) male and 27% female (13/48). The majority of the respondents were male.

The respondents were divided into four age categories. Variety in the ages of the respondents was sought in order to elicit a range of viewpoints as to how they see their houses. The largest age group interviewed (58%, 28/48) ranged from 40-60 years old for both genders. About 29% (14/48) belonged to the age group of more than 60 years old and the smallest group (13%, 7/48) was from ages less than 40 years old. This gives a good

indicator that the respondents have had enough experience to judge in this study. Although there is not an even split across the age categories, all age categories are represented.

Every participant voluntarily indicated their age. On this basis, they were categorized into 73% males (35/48) and 27% females (13/48). The highest number of respondents were males.

There were 48 participants in the expert panel of this study. Their work experience was related to practice, decision-making, research and academia. They all had experience and recognition locally and internationally for their work. The members of the panel were selected from the private sector as well as both governmental and non-governmental organizations in order to achieve a balanced representation, as is shown in Table 3.2.

Table 3.2: *Expert panel's composition*

Category	***No.***	***Expert Description***
Academics	17/48 (35%)	Established academics (PhD holders) who research and work in the fields of energy efficient design and vernacular architecture.
Decision-makers	16/48 (33%)	Decision makers with experience in low-energy buildings and vernacular architecture. These experts have original qualifications in Civil Engineering, Built Environment and Architecture. They are responsible for granting planning permission in line with local regulations.
Building Professionals (in practice)	9/48 (19%)	Engineering consultants and construction practitioners in building design
International	6/48 (13%)	Experts from international companies with experience of an Iraqi context and the field of environment design.

Table 3.2 shows that the total number of the expert panel with experience is 48. There are 35% academic professionals (17/48) in the two phases. Decision makers accounted for 33% (16/48) in both phases. The percentage of building professionals accounted for 19% (9/48) in both phases. The percentage of the expert panel from worldwide corporations with knowledge of an Iraqi context and the field of environment design accounted for 13% (6/48). Each expert had a different experience as this depended on his/her particular roles as well as the sector in which he/she works. However, this study considered experts who were aware of the construction industries, as well as who had an idea about vernacular architecture and low-energy design, as summarized, in Table 3.3, below:

Table 3.3: *Expert panel's*

Academics	17 expert participants were selected due to their research experience in this area. They were assumed to be able to provide innovative design approaches and new methods currently employed around the world. The academics considered were either lecturers or professors at Iraqi universities.
Decision Makers	16 expert participants were selected who worked with various governmental ministries. They have also taken part in several decision-making processes. These include architects and engineers who have been employed at Ministries of Housing and Municipality or at other relevant Ministries that are associated with construction. Part of the expertise valued in these respondents related to Iraqi regulations and policies as well as decision making. In addition, the impact of policies on the overall construction industries was also looked for, specifically regarding the conservation of energy.
Building Professionals (In practice)	Nine expert participants were selected who were in practice as engineering experts or construction participants. Their perspectives were valued due to their experiences as consultants. Also, their skills focus on how to connect vernacular building design and energy-efficient design based on market demand and the availability of construction resources. This group represented various specialisms including real estate developers, construction companies and engineering consultant agents.
International	Six expert participants were from international companies with experience of an Iraqi context and the field of environment design were selected. Their perspectives were valued due to their experiences as consultants.

3.2.3.2 Sampling Techniques

A survey distribution procedure using manual printed questionnaires was employed in the research. Although this is slower and more expensive in comparison with an online survey (Stanton, 1998, Weible and Wallace, 1998), it can be more efficient, particularly when the snowball sampling system is used (Biernacki and Waldorf, 1981), which enabled the large-scale circulation of surveys in Baghdad. In this system, the author distributes the questionnaire to a participant who also passes the author across to other participants. This is very beneficial in attaining a high rate of participation and at the same time gathering and recognizing sources that have a certain level of knowledge (Bird, 2009). The procedure was undertaken in Baghdad between February 2017, July 2017 and August 2017. The survey was facilitated by face-to-face interviews; the questionnaire was distributed by hand to individuals in Baghdad. The generated responses from the survey and the outcomes were evaluated by the researcher.

3.2.3.3 Ethical Considerations

An ethics approval form was submitted to the Welsh School of Architecture/Cardiff University and approved. All respondents completed a consent form, which explained the purpose of the survey and assured them that their data would be held confidentially.

3.3 Summary

This chapter has demonstrated the various methods that were used in this research to fulfill the objectives of this study. The four important stages involved are:

- **Application of knowledge from literature:** Reviewing of previous literature in order to understand the current state of knowledge in this field of study and provide an academic basis for the choice of passive design strategies (See Chapter Two).
- **Bioclimatic analysis using psychrometric chart for Baghdad:** Analysing feasible passive design strategies for application in Baghdadi climate (See Chapter Four).
- **Public perception survey:** Analysing the public's satisfaction with both contemporary and vernacular houses with regards to environmental and cultural performance. This information was used to inform decisions on which passive design strategies to implement in the design strategy for new housing in Baghdad (See Chapter Five).
- **Expert perception Survey:** Analysing experts' perceptions on the potential inclusion of passive design strategies in future Baghdadi housing designs (See Chapter Six).

These four methods enabled the establishment of design strategies for new housing units in Baghdad. It is anticipated that this will require a combination of contemporary technology with passive design fundamentals to provide occupant comfort while reducing energy consumption compared to contemporary Baghdadi housing.

Chapter 4

Bioclimatic analysis using psychrometric chart for Baghdad

4.1 Introduction

This chapter responds to ***objective 1*** of this research, and it identifies, analyses, and implements climatic strategies that have an influence on reducing the consumption of energy along with taking into consideration the plausible solutions for construction attained at active and passive levels.

The research study offers insights into setting up various design strategies for new residential units in Baghdad. It focuses on improving the occupants' thermal comfort as much as possible using passive strategies before using energy efficient technologies for buildings. The traditional use of passive design strategies in vernacular architecture can also provide enhanced and naturally appealing housing solutions that fulfill social and functional demands.

A bioclimatic analysis for Baghdad, Iraq, was carried out using a psychrometric chart to identify possible climate appropriate passive designs for inclusion in sustainable constructions. This is an established research method, which has several investigations been used for this purpose in (Szokolay, 1986; Givoni, 1992; Ajibola, 2001; Lam et al., 2006; Milne et al., 2009; Tahbaz, 2011; Mahmoud, 2011; Shallcross, 2012; Al-Azri, Zurigat, and Al-Rawahi, 2013; Katafygiotou and Serghides, 2015; Olgyay, V., 2015; Khambadkone and Jain, 2017; Ness et al., 2019; Ameur et al., 2020; Baghaei Daemei et al., 2020).

The psychrometric chart was used in this research to evaluate and analyze the climatic characteristics in the city of Baghdad using the methodology described in Chapter 3 (section 3.2.2). This approach can assist developers, architects, residential owners, building contractors and students with concepts that identify the climatic condition of their locale more accurately and hence improve the construction of additional energy-saving and sustainable buildings. In this research, in specific, the results are intended to inform the design strategies being developed for Baghdad.

4.2 Bioclimatic analysis of a Building using a Psychrometric Chart

Psychrometric charts are used to analyze information about temperature changes, i.e. wet bulb and dry bulb, as well as the humidity (relative and absolute) of a particular location. The chart can be used to interpret the degree of comfort that the occupants can depend on and hence identify appropriate passive strategies for a particular climate.

A range of methods can be used to calculate the comfort zone (see Section 3.2.2). A psychrometric chart can also be used to calculate how the comfort zone can be extended if specific passive strategies are implemented. An example of such a chart is shown in Figure 4.1, where extended comfort zones for the design strategies are itemized.

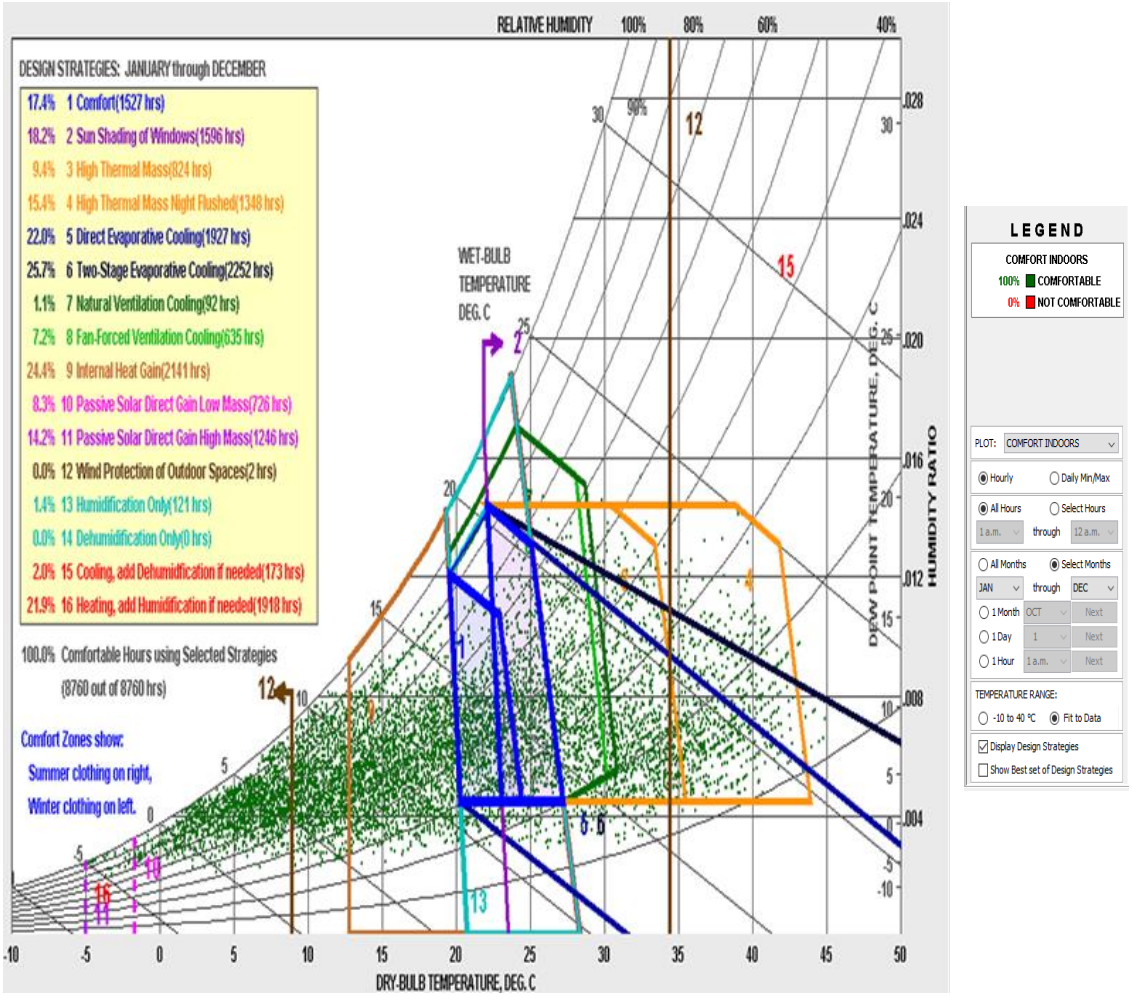


Figure 4.1: *Psychometric chart for a Baghdad building, showing strategic boundaries and the comfort zone.*

In Figure 4.1, various boxes define particular zones. The dark blue box represents the comfort zone for the buildings occupants when no passive design strategies are applied, while the other colors represent the expanded comfort zones specific to application of the various design strategies.

This example of a psychrometric chart was generated using Climate Consultant (6.0), as mentioned in Chapter 3, section 3.2.2). It represents the relationship between temperature and humidity; thus, it becomes much easier to express human thermal comfort and design passive strategies to meet the energy requirements that are much needed within the building (Berge & Mathisen, Perceived and measured indoor climate conditions in high-performance residential buildings, 2016).

The primary aim of this section is to carry out a bioclimatic analysis of a building that relates to the present conditions of climate change and thus to identify passive design approaches for the building that will ensure comfort for the people within it.

In Chapter 2, section 2.2.5, Baghdad's climate is described as that of an arid desert environment, with extremes of dry heat and sunny spells. The year has two seasons of extreme weather: the cold and rainy season (winter season) which lasts from December to February, with minimum temperatures below 2° and while the maximum temperatures are below 18°C and the hot and dry season (summer season) from the end of April to the end of December, when the heat regularly reaches above 50°C and does not often drop below 30°C.

As mentioned in Chapter 3, Section 3.2.2, the software used in the present study incorporates the ASHRAE Standard 55- 2005 comfort model. The analysis with a psychrometric chart in this section is based on the selection criteria for the comfort model. This research use the charts based on the comfort indoor plot option of Climate Consultant 6.0. For the comfort model, different percentages are offered for the similar passive cooling and heating design strategies for every month of the year.

Psychrometric chart is developed for each season and should thus be analysed in accordance with seasonal changes. The results of the analysis in this chapter are intended to inform the design strategies being developed for Baghdad;

4.2.1 Summer

It is essential to consider the factor of thermal comfort in the summer (see Table 4.1).

Table 4.1: *Analysis of hours of comfort achieved by specific passive design strategies based on bioclimatic analysis for Baghdad zone\ Summer*

Seasonal strategy	**Summer** **End April-End December**	**Hours**	**%**
	Comfort	1011	27.5%%
Cooling	Sun Shading of Windows	1318	35.9%
	High Thermal Mass	736	20.0%
	High Thermal Mass Night (Flushed)	1347	36.7%
	Direct Evaporative Cooling	1634	44.5%
	Natural Ventilation Cooling	427	4.9%
Systems	Cooling, add Dehumidification if needed	180	4.9%
100% comfortable hours using selected strategies (3671 out of 3672)			

Table 4.1 gives an analysis of the cooling design strategies defined in the selection criteria. According to Table 4.1 and Figure 4.2, the comfort conditions can be achieved 100% of the period. The significant passive design strategies for summer that are as follows: Window Shades for 1318 hours (35.9%), Direct Evaporative Cooling 1634 hours (44.5%), Natural Ventilation 427hours (4.9%), High thermal mass at night 1347 hours (36.7 %), and high thermal mass 736 hours (20.0 %). Thermal mass is important; thermal mass at night relates to the night-time ventilation strategy, but during the day every effort is made to prevent air from entering the building because it brings heat in with it. Two Stage Evaporative cooling is not included, since it is an active approach, whereas this research is trying to establish how good design can provide comfort without mechanical services.

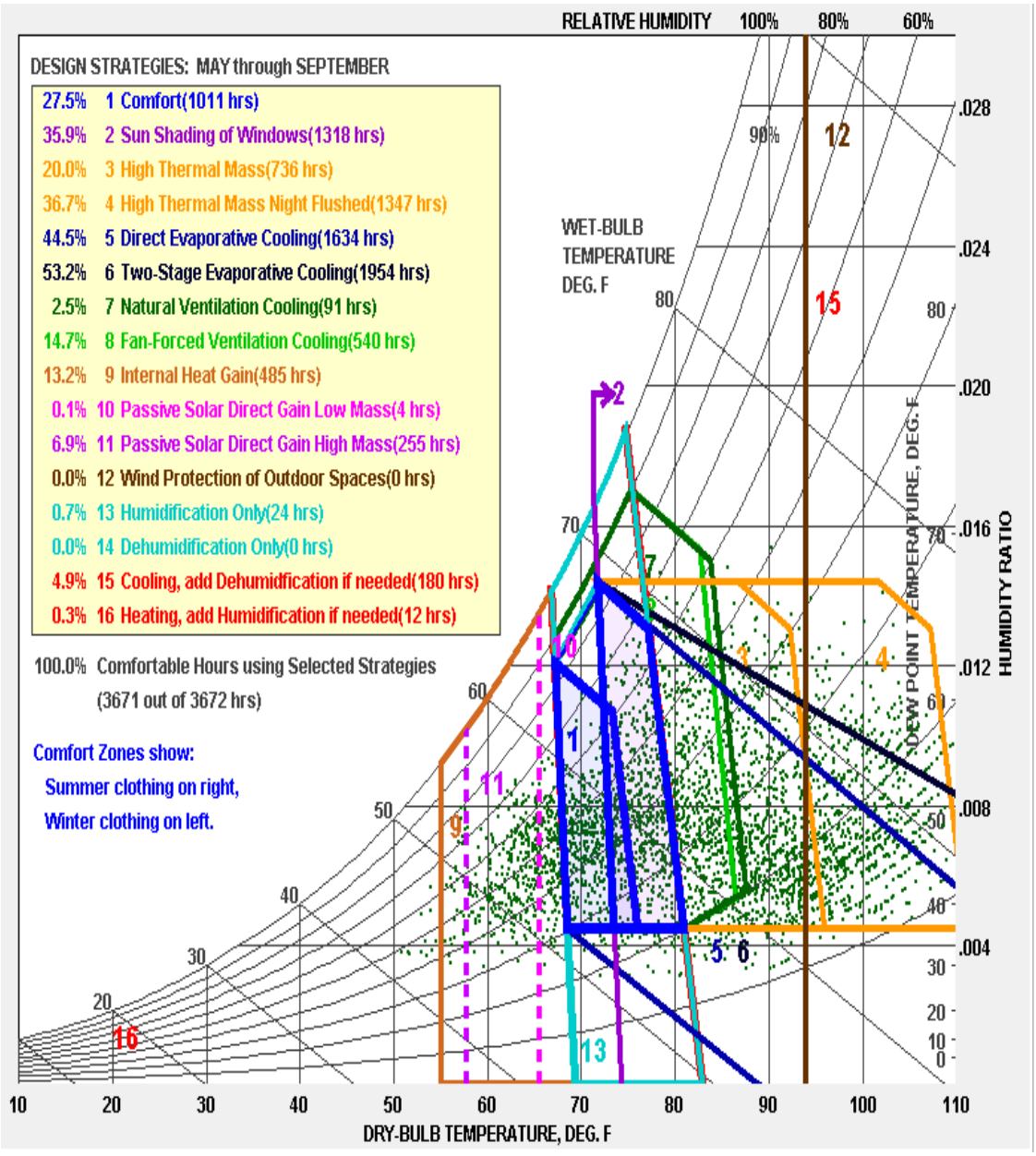


Figure 4.2: *Psychometric chart for Summer, Baghdad.*

The psychrometric chart shown in Figure 4.2 summarized in Table 4.1 shows that shading from the sun and direct evaporative cooling are the significant passive strategy that are commonly applied in hot and humid climates. Shading devices to control the temperature are recommended. By shading a building or minimizing the surfaces of it that are exposed to the sun, they provide an alternative way to reduce the solar gain that affects buildings. In fact, the best shading strategies lower the energy load by 10-20%.

The other significant passive strategy is direct Evaporative Cooling. The Evaporative Cooling proportion of the psychrometric chart is related directly to the building's capacity to allow water evaporation, which takes place at a known level of relative humidity. In dryer air, the amount of cooling will be much greater. Usually, the humidity level at the start of the day is quite high compared to the level later in the day, when it is reduced by the rise in the temperature increase. Moreover, during the day the air becomes dryer as the weather gets hotter. This eventually increases the rate of evaporation of water. However, the water temperature generally has no great influence on the process of cooling that evaporation produces (Erell, 2013). Evaporative Cooling is widely used in areas where water is in short supply because of its specific water features or the use of gunny bags or earthenware pots.

Natural ventilation is a passive strategy that is commonly applied in a hot and humid climate. It has an immense impact on the orientation of buildings and on window design because it promotes comfort indoors. Architectural planning in such a climate must provide cross ventilation by designing to allow free flow of air in the prevalent breezes. Architectural features, specifically all types of openings (windows, patios, doors, ventilators, and courtyards, have the potential to active keep people cool. These features must be protected by shading devices (both horizontal and vertical) and recess openings. Natural ventilation is one of the passive cooling techniques that function well when coupled with the cross-movement of air. The effects of natural ventilation can be strengthened by the installation of fans.

By replacing warmer internal air with cooler outdoor air, natural ventilation removes heat (sensible and latent) from buildings. To integrate this passive strategy into a building, the following parameters must be considered: fly screens and internal partitions, shading equipment, room volume, inlet and outlet sizes, penetration areas and the directions of the wind. If a building can be designed using this passive strategy, a pleasant level of ventilation can be achieved (Awbi, 2002).

4.2.2 Autumn

It is equally important to keep in mind the factors of thermal comfort during the Autumn season (see Table 4.2).

Table 4.2: *Analysis of hours of comfort achieved by specific passive design strategies based on bioclimatic analysis for Baghdad zone\Autumn*

Seasonal strategy	Autumn Oct. -Dec.	Hours	%
	Comfort	270	12.2%
	Sun Shading of Windows	164	7.4%
	High Thermal Mass	135	6.1%
	High Thermal Mass Night	143	6.5%
	Direct Evaporative Cooling	201	9.1%
	Natural (Adaptive comfort)Ventilation Cooling	10	0.5%
	Internal Heat Gain	794	36.0%
	Passive Solar Direct Gain Low Mass	248	11.2%
	Passive Solar Direct Gain High Mass	144	6.5%
	Wind Protection of Outdoor Spaces	0	0%
	Humidification Only	50	2.3%
Systems	Cooling, add Dehumidification if needed	0	0%
	Heating, add Humidification if needed	846	38.3%

Table 4.2 gives an analysis of the design strategies defined in the selection criteria. According to Table 4.2 and Figure 4.3, the comfort conditions can be achieved 100% (2208 hours) of the period. The significant passive design strategies for Autumn that are as follows: Passive Solar Direct Gain Low Mass 248 (11.2%), Shading of windows from the Sun 164hours (7.4%), Direct Evaporative Cooling 201 hours (9.1%), Passive Solar Direct Gain High Mass 144 hours (6.5%), and also Natural Ventilation 10 hours (0.5%).

The Autumn season is quite dry and the temperature is higher than in Winter. However, the temperatures gradually decrease.

In this season, thermal mass, shading from the sun, and direct evaporative cooling can be useful design strategies. The building orientation plays a much more important role during this season than it did in the Summer (Jovanović, Pejić, Djorić-Veljković, Karamarković, & Djelić, 2014).

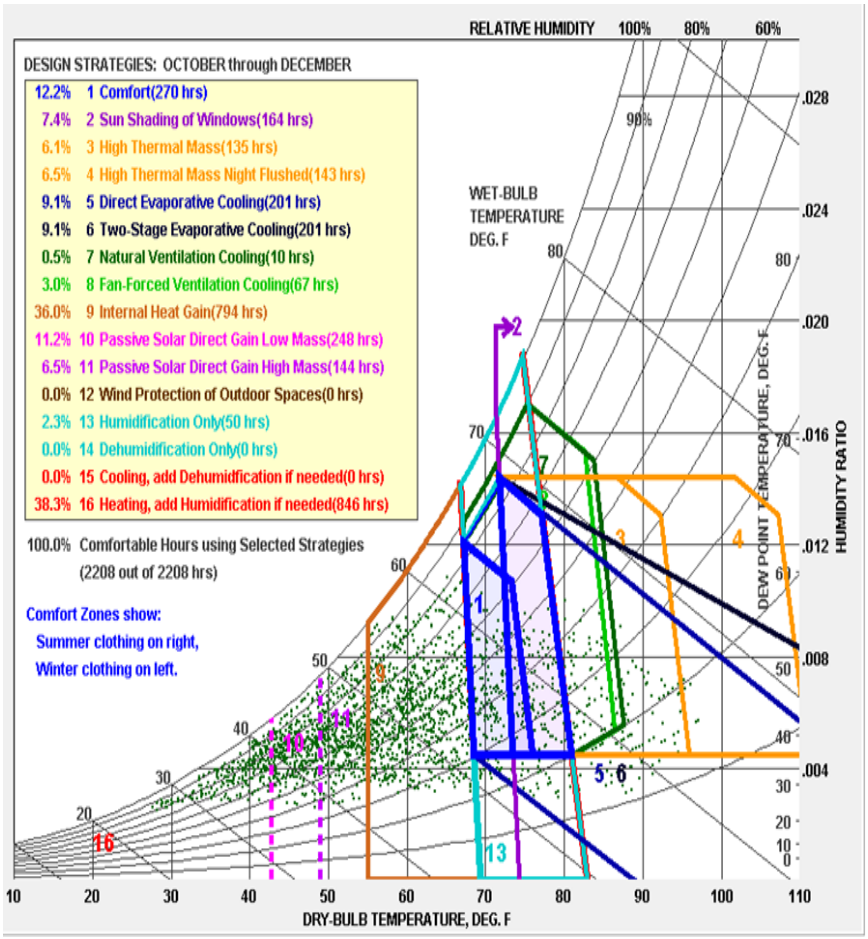


Figure 4.3: *Psychometric chart for Autumn Baghdad city.*

4.2.3 Winter

It is essential to bear in mind the factor of thermal comfort in Winter (see Figure 4.3).

Table 4.3: *Analysis of hours of comfort achieved by specific passive design strategies based on bioclimatic analysis for Baghdad zone\winter*

Seasonal strategy	Winter Dec.-Feb.	Hours	%
	Comfort	17	0.8%
Heating	Internal Heat Gain	411	19.0%
	Passive Solar Direct Gain Low Mass	384	17.8%
	Passive Solar Direct Gain High Mass	36	1.7%
	Wind Protection of Outdoor Spaces	2	0.1%
	Humidification Only	0	0.0%
	Dehumidification Only	0	0%
Systems	Cooling, add Dehumidification if needed	0	0%
	Heating, add Humidification if needed	1525	70.6%

Table 4.3 gives a comparative analysis of the design strategies defined in the selection criteria. The significant passive design strategies for winter are as follows: Passive Solar Direct Gain Low Mass: 384 hours (17.8%) and Passive Solar Direct Gain High Mass: 36 hours (1.7%). Low mass direct gain usually relates to cold day-time periods (when the sun is wanted immediately to warm a cool space). High mass direct gain usually relates to cold night-time periods (when the heat s to be stored and released). To include both of these, a design might show low thermal mass spaces in rooms used during the day which are oriented to receive morning/early afternoon sun and high thermal mass spaces in rooms used during the evening or at night which are oriented to receive the sun all afternoon. In addition, wind protection of outdoor spaces is required in the Winter for 2 hours (0.1%).

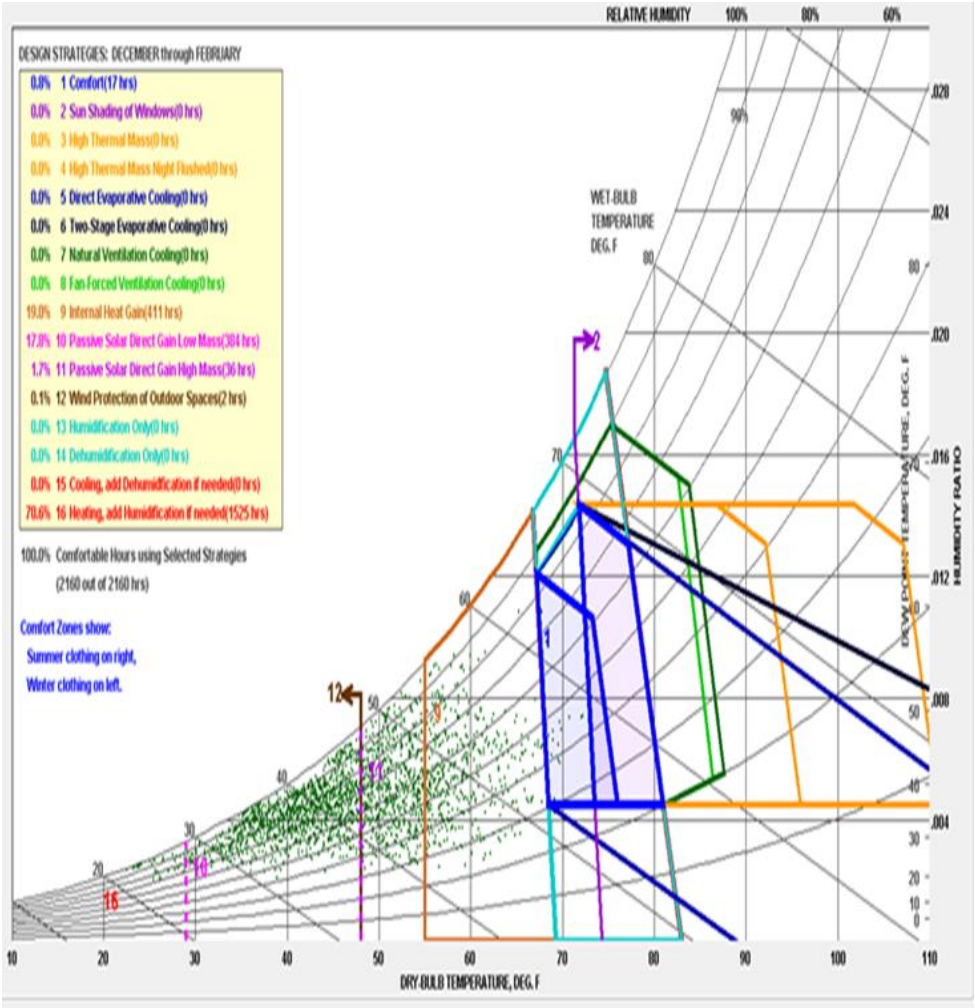


Figure 4.4: *Psychometric chart for Winter Baghdad city*

As the temperatures are below the comfort zone in winter it is essential to take advantage of solar energy for passive heating. This is achieved by orienting the building and making it open to the sun. However, this conflicts with the requirement for solar shading in Summer, a contradiction that must be addressed in the overall design. The passive solar heating can be combined with thermal mass (e.g. concrete floors or stone walls) inside the building to store heat in Winter, thus ensuring the comfort zone (Figure 4.3).

4.2.4 Spring

Thermal comfort is still a matter of concern in the Spring season (see Table 4.4).

Table 4.4: *Analysis of hours of comfort achieved by specific passive design strategies based on bioclimatic analysis for Baghdad zone\Spring*

Seasonal strategy	Spring	Hours	%
	Comfort	250	11.7%
	Sun Shading of Windows	117	5.5%
	High Thermal Mass	37	1.7%
	High Thermal Mass Night	37	1.7%
	Direct Evaporative Cooling	69	3.2%
	Natural Ventilation Cooling	5	0.2%
	Internal Heat Gain	777	36.4%
	Passive Solar Direct Gain Low Mass	350	16.4%
	Passive Solar Direct Gain High Mass	148	6.9%
	Humidification Only	47	2.2%
	Heating, add Humidification if needed	926	43.5%

Table 4.4 gives a comparative analysis of the design strategies defined in the selection criteria. The significant passive design strategies for Spring that are as follows: Passive Solar Direct Gain Low Mass 350hours (16.4%), Shade for windows from the Sun 117hours (5.5%), and Natural Ventilation 5 hours (0.2%).

The psychrometric chart in Figure 4.5 represents the spring season. The direct solar heat gain that comes from the east- and west-facing glazing can be minimized during the Spring season by making use of exterior shading, which will keep the building mechanically cool, as well as helping to balance the humidity levels. It is essential to control the direct solar heat gain of the south-facing glazing to protect the building from maximum heat by using exterior horizontal shading elements.

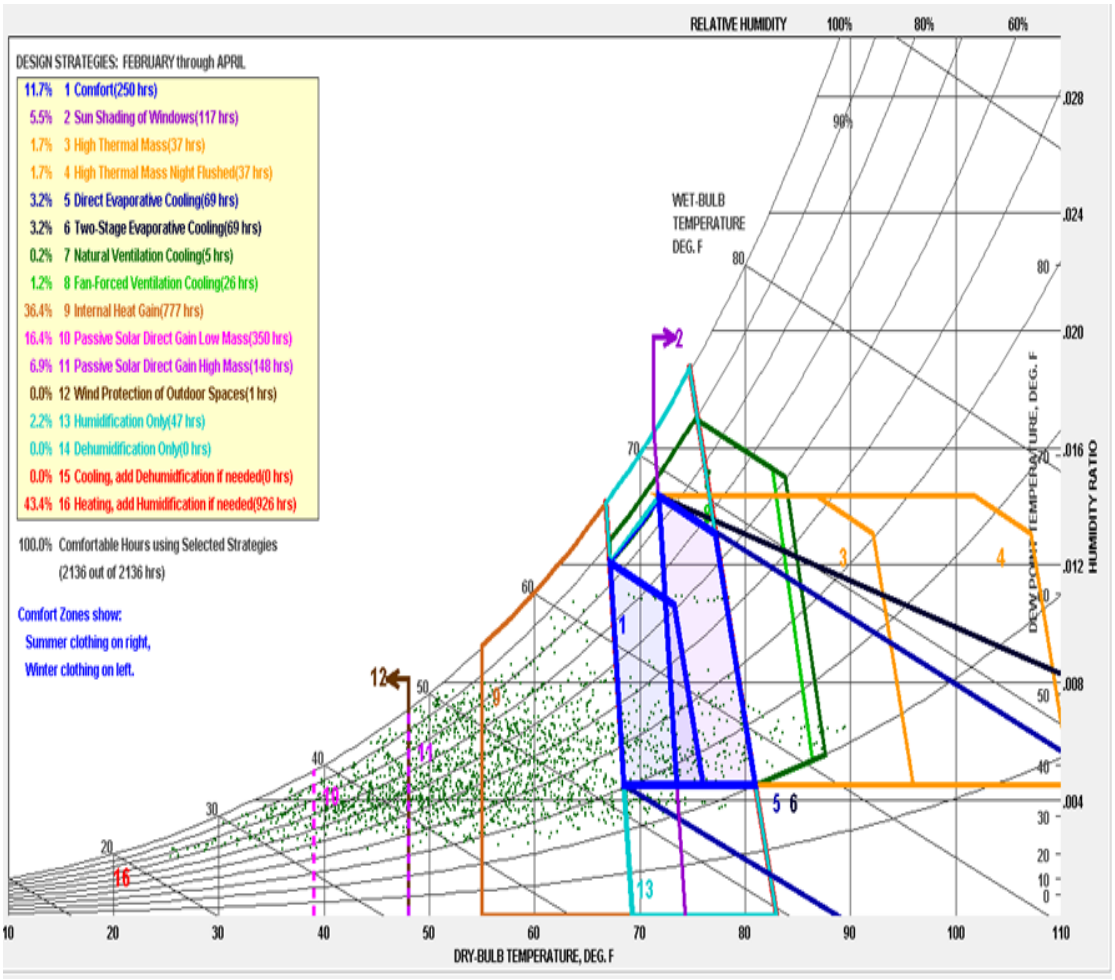


Figure 4.5: *Psychometric chart for spring \ Baghdad city.*

4.2.5 Overall Seasons

It is essential to consider the factor of thermal comfort for the year as a whole **(**see Table 4.5 and Figure 4.6).

For each of the four comfort models options, different percentage offer similar passive cooling and heating design strategies for the all the months of the year. Table 4.5 gives a comparative analysis of the results of implementing the cooling design strategies, as defined, over a whole year.

Table 4.5: *Analysis of hours of comfort achieved by specific passive design strategies based on bioclimatic analysis for Baghdad zone\Annual*

Seasonal strategy	Annual	Hours	%
	Comfort	1531	17.5%
Cooling	Sun Shading of Windows	1599	18.3%
	High Thermal Mass	908	10.4%
	High Thermal Mass Night	1527	17.4%
	Direct Evaporative Cooling	1904	21.7%
	Two-Stage Evaporative Cooling	2224	25.4%
	Natural Ventilation Cooling	633	7.2%
Heating	Internal Heat Gain	2142	24.5%
	Passive Solar Direct Gain Low Mass	726	8.3%
	Passive Solar Direct Gain High Mass	555	6.3%
	Wind Protection of Outdoor Spaces	2	0.02%
	Humidification Only	121	1.4%
Systems	Cooling, add Dehumidification if needed	180	2.1%
	Heating, add Humidification if needed	2355	26.9%

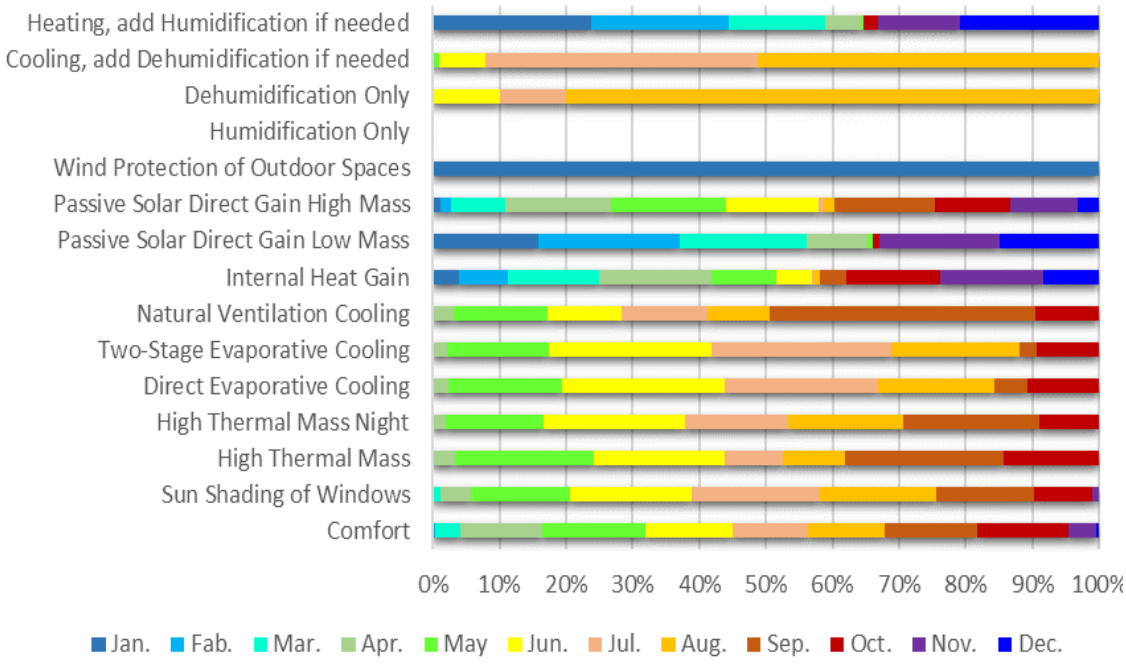


Figure 4.6: *Analysis of hours of comfort achieved by specific passive design strategies based on bioclimatic analysis for Baghdad zone*

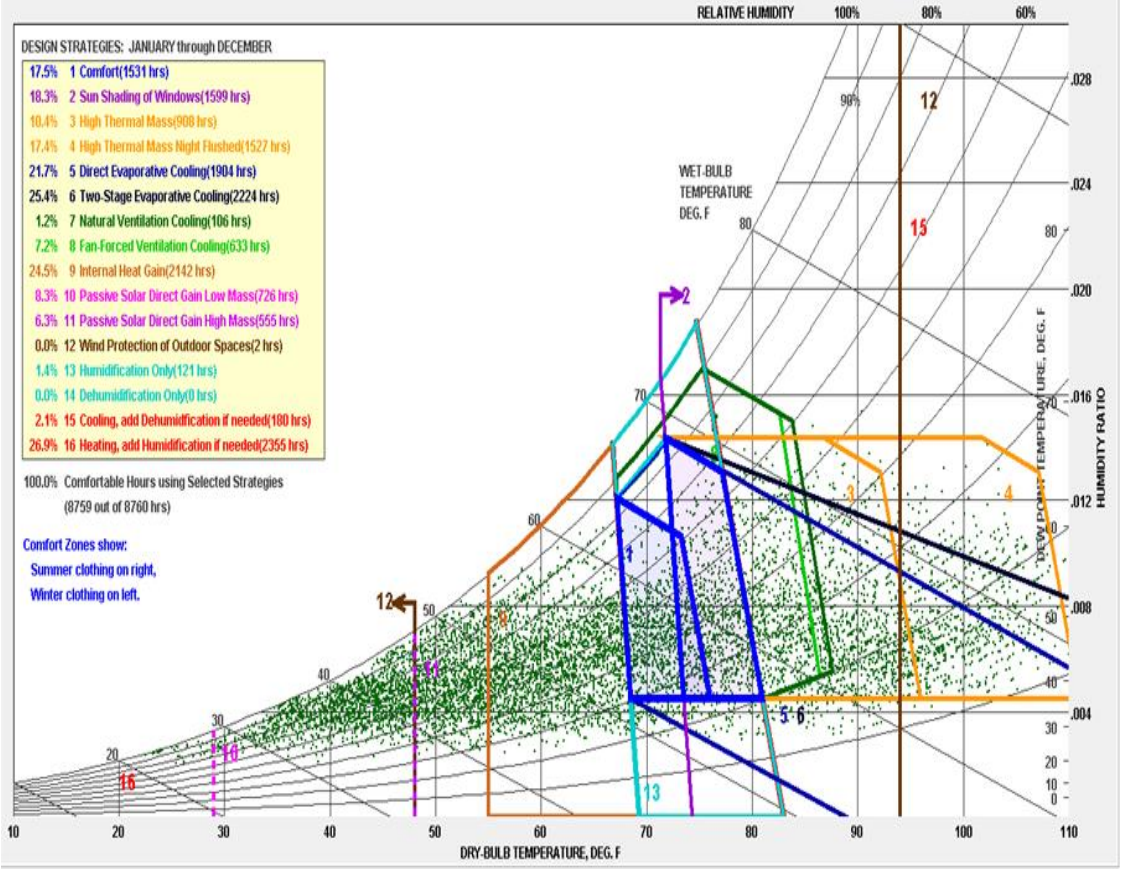


Figure 4.7: *Psychometric chart for the whole year \ Baghdad city.*

Table 4.5 gives an analysis of the design strategies defined in the selection criteria. The significant passive design strategies for summer that are as follows: Shade for Windows from the Sun 1531 hours (17.5%), Direct Evaporative Cooling 1904 hours (21.7%), Natural Ventilation 106 hours (1.2%), High thermal mass night 1527hours (17.4%), and high thermal mass 908 hours (10.4%). Thermal mass is important; the night time thermal mass relates to a night-time ventilation strategy. In addition, every effort is made to prevent air from entering the building during the day because it brings the heat in with it. Two Stage Evaporative cooling (25.4%) is not included because it is an active approach, whereas this research trying to establish how much of the time comfort can be had without mechanical services. In colder weather, the main passive design strategies are Passive Solar Direct Gain Low Mass and High Mass (8.3% and 6.3% respectively). Low mass direct gain usually relates to cold day-time periods (when sun is wanted immediately to warm cool spaces). High mass direct gain usually relates to cold night-time periods (when the heat is stored and released later). To include both of these, a design might let the spaces which

are oriented to receive morning/ early afternoon sun and are used during the day have low thermal mass; and to reserve high thermal mass for spaces used in the evening or at night and are oriented to receive sunlight all afternoon. It may be seen in the Psychometric chart for the whole year that Spring and Autumn each have a higher number or percentage of hours within the comfort zone. than in the Summer and Winter

From the seasonal analysis, it can be concluded that the design strategies of the building must incorporate features to provide passive cooling in summer as well as passive heating in winter to maximize the number of hours in comfort within the building.

Building orientation and the resulting glazing orientation are directly related to shading and passive solar heating and are critical factors to optimize. Brick for the exterior walls could also be a suitable construction material. Although there is no solar exposure on the northern external wall, it is still capable of having a high thermal mass. Flat roofs work well in this climate especially if light in color. Air conditioning can be reduced or eliminated by good natural ventilation, if windows are well shaded and oriented to the prevailing breezes; moreover, open plan rooms promote natural cross-ventilation. Shading is analogous to placing a cap on the building to block the solar radiation from entering it. Deciding the place and time for shading can significantly affect the relaxation levels within enclosed spaces. Double glazing with a low E-value on the east, west and north sides but not on the south maximizes passive solar gain.

An analysis of the Psychometric chart each season and also for the whole year provides the following key findings:

- There are periods when the building requires passive solar heating because Iraq has sufficient solar irradiation to support this during the daytime.
- As expected, the coolest periods are during the night, so solar energy should be captured and stored to keep buildings warm at night; this also has the advantage of reducing overheating during the day.
- There are periods when passive cooling is required to prevent overheating. These are most severe during the daytime.

The key passive cooling strategies are shading, thermal mass, natural ventilation and evaporative cooling. Shading prevents solar heat from entering the building. Thermal mass delays the penetration of the building by external heat and can be used to obtain

thermal storage, transferring the benefits of solar energy to times when it can be useful or can at least lessen the impact of the heat on the occupants. Natural ventilation and evaporative cooling are both strategies which can remove heat from space.

Some locations of the building need more careful design than others. This can be due to high usage or to high exposure. For instance, a living room has high occupancy during the day, a bed room has high occupancy at night. Both need to be more comfortable than a circulation space which is used only briefly. The roof will experience more solar energy than any other building surface, so careful attention is required so that the roof prevents excess heat from being absorbed by the spaces immediately below.

Table 4.5 and Figure 4.6 and 4.7 show that there are 1531 hours (17.5%) of a year that do not need heating or cooling. Table 4.5 shows that the significant passive design strategies for summer include Shading, high thermal mass at night, High thermal mass, Direct Evaporative cooling, and Natural ventilation cooling. In the colder Winter season, however, the main passive design strategies are Passive Solar Direct Gain Low Mass and High Mass. Sun shading strategies are still required in winter.

Spring and Autumn in Baghdad experience temperatures which require passive cooling strategies. These seasons can also benefit from shading, thermal mass, and natural ventilation for high-temperature periods. However, these seasons also have periods which require passive solar heating; this should be linked with thermal mass to allow thermal storage until night-time when it is most needed, particularly in April and October.

It is acknowledged that mechanical services may be needed in some months to achieve comfort where passive strategies are not sufficient (Figure. 4.6 and Table 4.5).

According to climate data for Baghdad (Chapter 2\section 2.5.2), the summers are very hot but there is a rainy season in the Autumn. The winters are chilly, and temperatures fall to below freezing in January. The rainy seasons starts end of November and extends till January. The weather remains dry from June to August and these are the hottest months in summer since the clear skies have no rainclouds to mitigate the sunshine (Weather station, Baghdad airport 2018).

Inexpensive fossil fuels are available for heating in winter but in summer the use of air conditioners significantly increases the consumption of electricity. In vernacular houses,

the people of Iraq have changed their living patterns to find solutions for the problems of their hot climate. They organize their daily routines so as to accommodate the hot climate most comfortably. They use sleep on the open spaces of their flat house roofs to benefit from the cool breezes after 10 at night. They wake up early and reach their workplaces before the heat affects them. They return home in the early afternoon and have siesta in the basement after lunch, where it is cooler. In the evenings they spend their time in gardens or the courtyards of their homes, retiring to the roof to sleep. In Summer, this is their way of life in summer and is integrated with house activities. All vernacular houses are the suitability of the roof and basements design for use as a living space. The development of air conditioning systems when electricity was cheap abandoned the old simple methods of living. Buildings with vernacular features have now become more expensive and vernacular features are becoming prominent once more in Iraqi homes. Due to the increased prices of real estate, people are using vernacular methods and constructing low cost energy-efficient houses. New houses can manage to consume little energy use without additional construction costs by using passive design strategies. Electricity is very expensive and power generation is low therefore air conditioning options are unattractive.

If an effective strategy is not adopted to reduce the unwanted heat that goes into a building, the building will cause thermal discomfort. The results discussed in this chapter indicate that the most efficient passive strategies for the whole year for Baghdad are the solar shading of windows, natural ventilation, direct evaporative cooling, and heating along with added humidification if required. All these strategies can be incorporated within a building to achieve as many hours as possible of comfort, energy saving, and enhanced low energy use in the climate of Baghdad.

4.3 Conclusion

Bioclimatic design using a psychrometric chart as a tool can be very useful in prioritizing the passive strategies to be included in a building design. This approach has been used to identify the requirements for every season, making it possible to synthesize an “all-year” building design which emphasizes the elements that provide comfort for the greatest possible number of hours and ensures that they can work harmoniously with each other.

Appropriate aspects of this design will be considered in relation to public and expert opinion; please see Chapter 7.

The most efficient passive strategies for the whole year are solar shading for windows, natural ventilation, direct evaporative cooling, heating along with added humidification if required.

The design strategies that can be used are suggested for Baghdad, but each has already been adopted in one form or another since ancient times.

Table shows 4.6 a comparative of the results of implementing the passive design strategies identified in bioclimatic analysis and literature reviews.

Table 4.6: *A comparative of the results of implementing the passive design strategies identified in bioclimatic analysis and literature reviews.*

Bioclimatic analysis	***Literature reviews***	
Passive design strategies	***Passive strategies in vernacular architecture***	***Houses' elements or features***
Shading	Shading	Compact layout
		The courtyard
		The building form
Natural ventilation	Natural ventilation	The courtyard
		The internal spaces
		The wind – tower(Badgir)
		The building form
		The water& planting features
Evaporative cooling	Evaporative cooling	The courtyard
		The water& planting features

Chapter 5

Public Survey Analysis: Perception of vernacular design and contemporary homes

5.1 Introduction

This chapter responds to ***objective 2*** of this research, and it presents the analysing of the public's satisfaction with both contemporary and vernacular houses with regards to environmental and cultural performance. This information was used to inform decisions on which passive design strategies to implement in the design strategy for new housing in Baghdad. The respondents of this study are all from the Baghdad city and were currently residing in the city during the course of this investigative study. The city is known for its high energy consumption and CO_2 emission rates.

An interview questionnaire was provided to the participants, as described in the methodology listed in chapter three. The questionnaire focused on the existing building stock, the behaviour of occupants in terms of their energy use, and their perception of what constitutes to sustainable and low energy dwellings. The data collected were analysed using Microsoft Excel software. Tables and figures were used for illustration and analytic purposes.

This chapter is structured into three main sections: results and results and analysis, key findings, and finally a concluding summary.

The findings show a limited public awareness towards sustainable, low energy homes, as well as important social-cultural barriers to the delivery of low energy homes and large scale retrofitting of existing domestic stock.

5.2 Results and Analysis

The questionnaire reached 112 participants, 98 of whom (87.5%) were interviewed and completed it successfully. The respondents were very helpful in answering the questions, although the researcher had difficulties in explaining each question to every single respondent.

The questionnaire was administrated to a total of 98 respondents, of which 12/98(12%) represented vernacular houses. The researcher acknowledges the low proportion of candidates represented vernacular houses due to the fact that many vernacular houses and neighborhoods lost their original residents, and today vernacular houses were sub-

divided for multiple occupies by poorer households, as evidenced in literature review and personal observation.

The researcher has explained the reasons for doing the survey to the respondents. The respondents were told that the survey was important in order to establish occupant comfort and satisfaction, and the thermal performance of their house. Also, evaluation of the findings of the survey would be valuable in establishing design strategies and inform the design of the future house; as well as to help to identify and inform the development of solutions to existing housing problems. Moreover, an additional reason for the survey is to establish a comparison of the internal thermal environmental conditions between the vernacular and modern houses.

The respondents fully agreed to answer the research questionnaires of their houses and were pleased to answer the questionnaires. The survey was designed to consider the respondents experience and build upon the findings of literature informing a more up to date understanding of the experience of occupation of these two housing typologies in the current climate and socio-cultural context that remains unreported in existing literature. By evaluating the results of the survey, insightful data can be used to improve design of future homes and to identify solution to existing infrastructures. The full questionnaires are reproduced in English in Appendix A.

This chapter will present the results received from the questionnaire responses of the inhabitants on both vernacular house and contemporary house. The analysis of the differences in responses between inhabitants of the different house types will present through a comparison of findings from both house type to represent different inhabitants' opinions. Each question will be taken separately and will be considered in the light of all respondents who completed the survey.

The questionnaire analysis is divided into six parts:

I. Part A: Demographic information of the respondents' answers from both houses are presented together;
II. Part B: Local domestic stock typology and current problems;
III. Part C: Patterns of energy consumption and rates of energy use fulfilment;
IV. Part D: Public perception and knowledge about vernacular design via contemporary design

V. Part E: Public perception and knowledge of energy efficient housing;

VI. Part F: Public knowledge of energy retrofitting and sustainable energy homes,

VII. Part G: Cultural barriers in the delivery of low energy homes.

5.2.1 Part A: Demographic information

- **Gender and age of the respondents**

All respondents (98) of vernacular house and contemporary house were asked the following questions:

Q1: Gender?		Male
		Female
Q2: Age?		From 18-24
		From 25-34
		From 35-49
		From 50-60
		More than 60

This question investigated the respondent's gender and age.

Table 5.1: *Respective gender and age ranges in both house types*

	Age	**18-24**	**25-34**	**35-49**	**50-60**	**More than 60**	**Total**	**%**
Vernacular house	Male	1	4	0	2	2	9	9%
	%	11%	45%	0%	22%	22%		
	Female	0	2	0	1	0	3	3%
	%	0%	67%	0%	33%	0%		
Contemporary house	Male	2	24	8	3	4	41	42%
	%	5%	58%	21%	7%	10%		
	Female	1	23	13	6	2	45	46%
	%	2%	51%	29%	14%	4%		
Total		4	53	21	12	8	98	
Percentage		4%	54%	21%	12%	8%	100%	

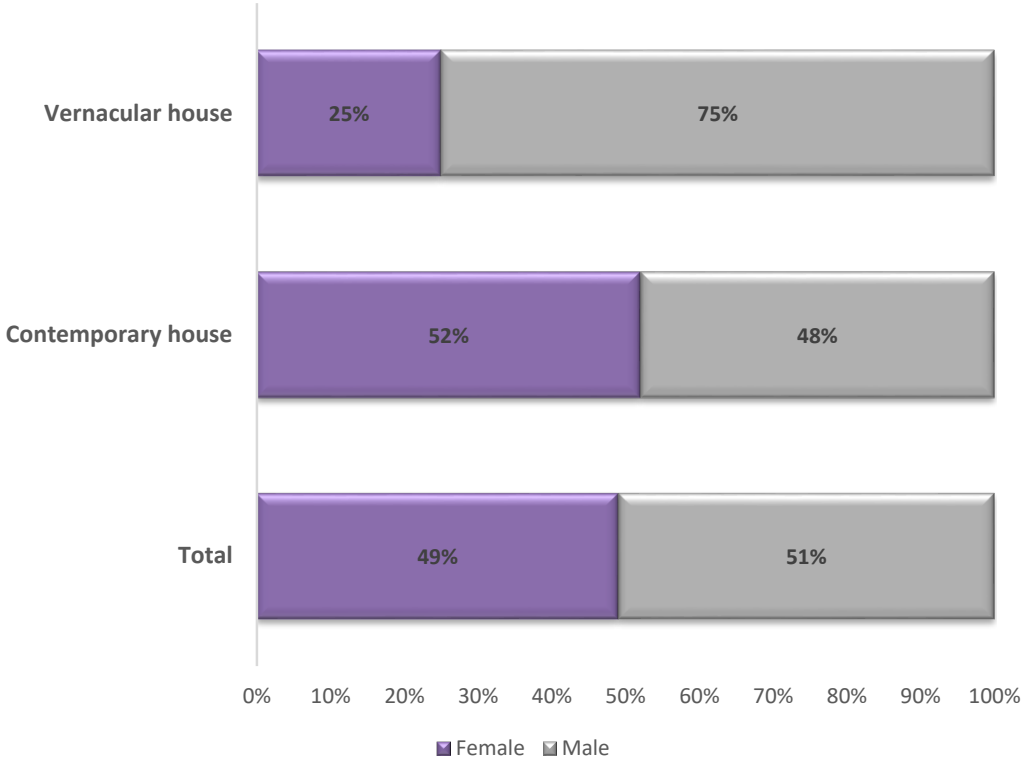


Figure 5.1: *Respondent's gender in both house types*

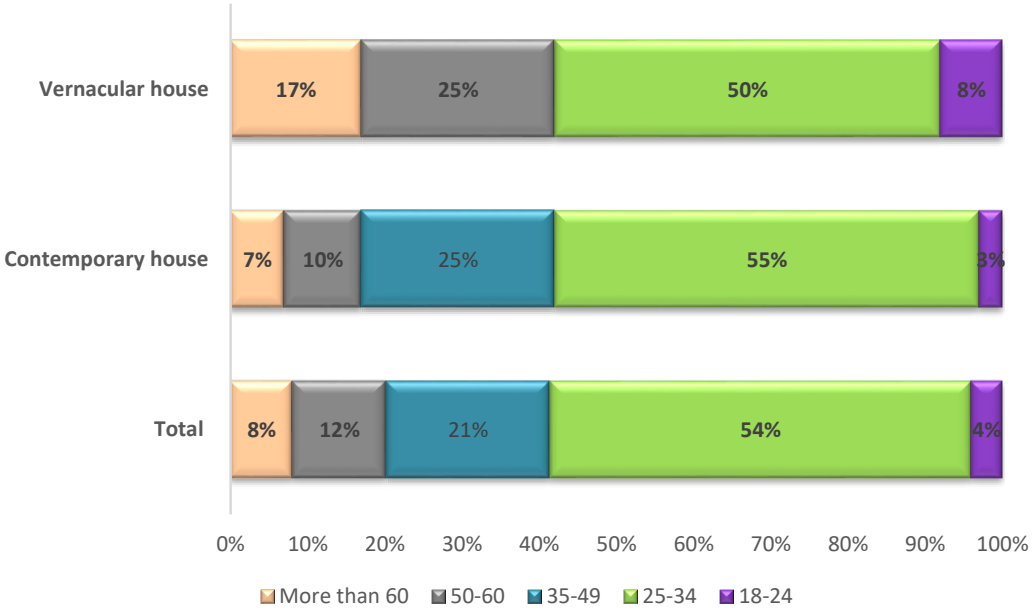


Figure 5.2: *Respondent's age rang in both house types*

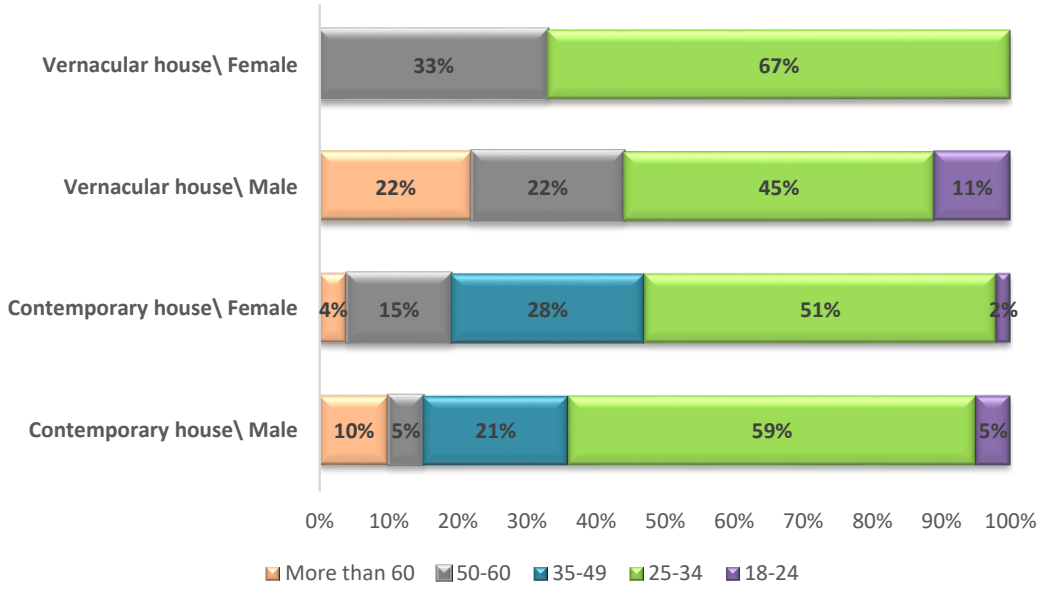


Figure 5.3: *Respondent's gender and age in both house types*

As shown in Table 5.1 and Figure 5.1, the distribution of gender in this survey in the contemporary house section was 42% (41/86) males and 46% females (45/86), whereas the number of female's respondents in the vernacular house was 25% (3\12) while 75% (9/12) of men took part in the survey.

As demonstrated in Table 5.1 as well as Figure 5.1 and 5.3, all of the participants (98) stated their gender, based on which, they were split into 50/98 (51%) males and 48/98 (49%) females. The majority of the respondents were male. The percentage of females taking part (49%, 48/98) was of sufficient number to give a satisfactory reflection of their opinions, as seen in Figure 5.2. This represents Baghdad's larger population of which males outnumber females (Ministry of Planning\Iraq, 2018).

As demonstrated in Table 5.1 as well as Figure 5.2, the respondents were divided into 5 age categories. Variety in the ages of the respondents was sought in order to elicit a range of viewpoints as to how they see their houses. The largest age group interviewed (75%, 74/98) ranged from 25-49 years old from both genders. About 12% (12/98) belonged from the age group between 50-60 years old and the smallest group (4%, 4/98) was from ages less than 24 years old, while 8% (8/98) were more than 60. This suggests that the data reflects the median age of the Iraq population is over 20 years of age, according to latest

demographic report (Ministry of Planning\Iraq, 2018; Statista, 2019) (Fig. 5.4). This gives a good indicator that the respondents have had enough experience to judge their dwelling. This possibly indicates that a higher number of homeowners contributed to this study.

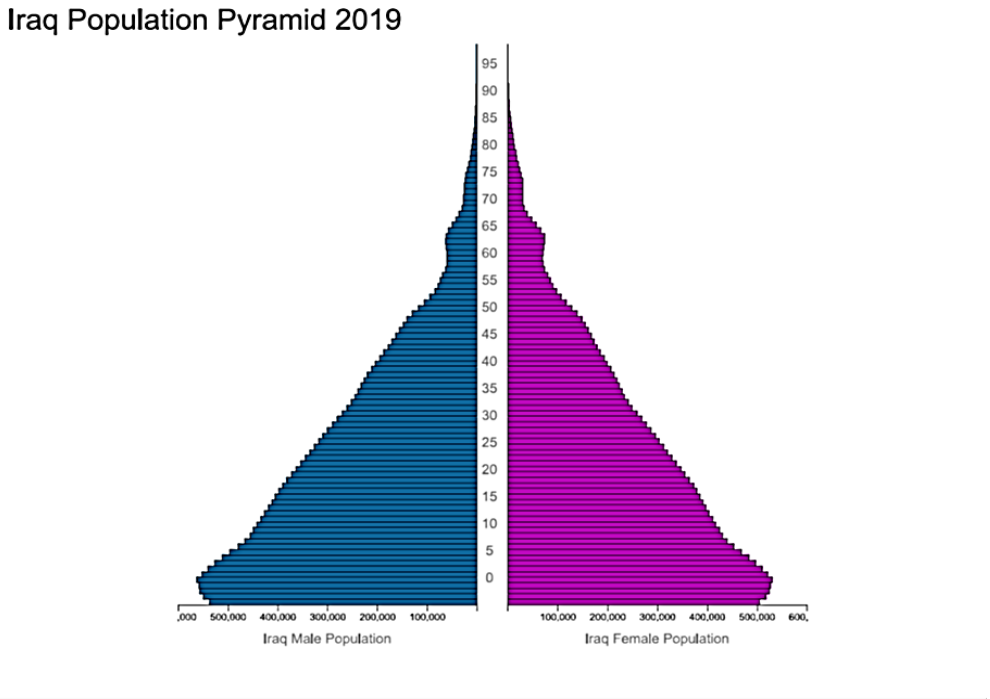


Figure 5.4: *The median age of the Iraq population*

- **Academic education level**

All respondents (98) of vernacular houses and contemporary houses were asked the following question:

Q3: What is your highest qualification?		Diploma
		Bachelor's Degree
		Master Degree
		Ph.D. Degree

The level of education is considered as an important aspect that may influence respondents' opinions towards and understanding of the content of this questionnaire, in particular, relating to architecture and housing conditions.

Table 5.2: *Academic educational levels*

Education	*Diploma	Bachelor's *Degree	Master Degree	Ph.D. Degree	Total	
House	No.	No.	No.	No.	No.	%
Vernacular house	7	3	2	0	12	
Percentage	58%	25%	17%	0%		12%
Contemporary house	3	44	27	12	86	
Percentage	4%	51%	31%	14%		88%
Total	10	47	29	12	98	
Percentage	10%	48%	30%	12%	100%	

***Diploma:** Diploma is considered to be a short-term certification lasting up to 2 years or less and training provided is in a specific field or program. This creates a large job market and is a fast way to gain employment.

***Degree:** A degree is a longer-term commitment lasting 4 years or more. The level of expertise gained is significant and the information learned is a lot more in depth. The career growth of a degree is much higher than a diploma.

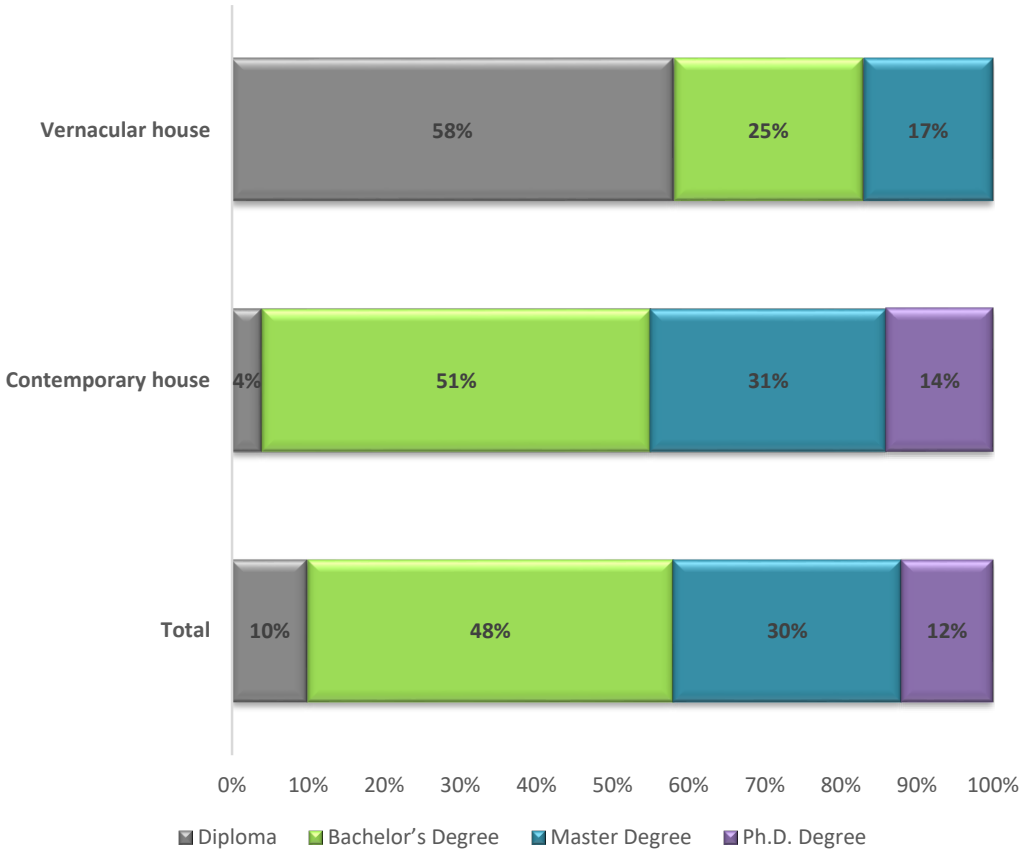


Figure 5.5: *Academic educational levels*

Table 5.2 and Figure 5.5 show the different education levels achieved by the respondents, divided into four main groups. Shown in the table (5.2), majority (48%, 47/98) hold a university certificate (bachelor's degree) followed in number by those who hold master's degrees 30% (29/98), while 12% (12\98) have a Ph.D. degree. These figures mean that the respondents were able to understand the questions intellectually. Conversely, majority of respondents in the vernacular area hold only Diploma certificates (7\12,58%); accordingly, they needed help in understanding the questions.

Furthermore, based on earlier statistical reports (BTI, 2018); the adult literacy rate for both genders was 79.7% in 2014.

- **Number of occupants within a family**

All respondents (98) of vernacular house and contemporary house were asked the following question:

Q4: How many occupants are there in your home?		1-2
		3-4
		5-8
		More than 9

This question was asked for investigating total numbers of family members who live in the same house.

Table 5.3: *Number within the family*

No. within the family	**1-2**	**3-4**	**5-8**	**More than 9**	**No.**
Vernacular house	**0**	**2**	**7**	**3**	**12**
Percentage	0%	17%	58%	25%	12%
Contemporary house	**6**	**15**	**54**	**11**	**86**
Percentage	7%	17%	63%	13%	88%
Total	**6**	**17**	**61**	**14**	**98**
Percentage	6%	18%	62%	14%	100%

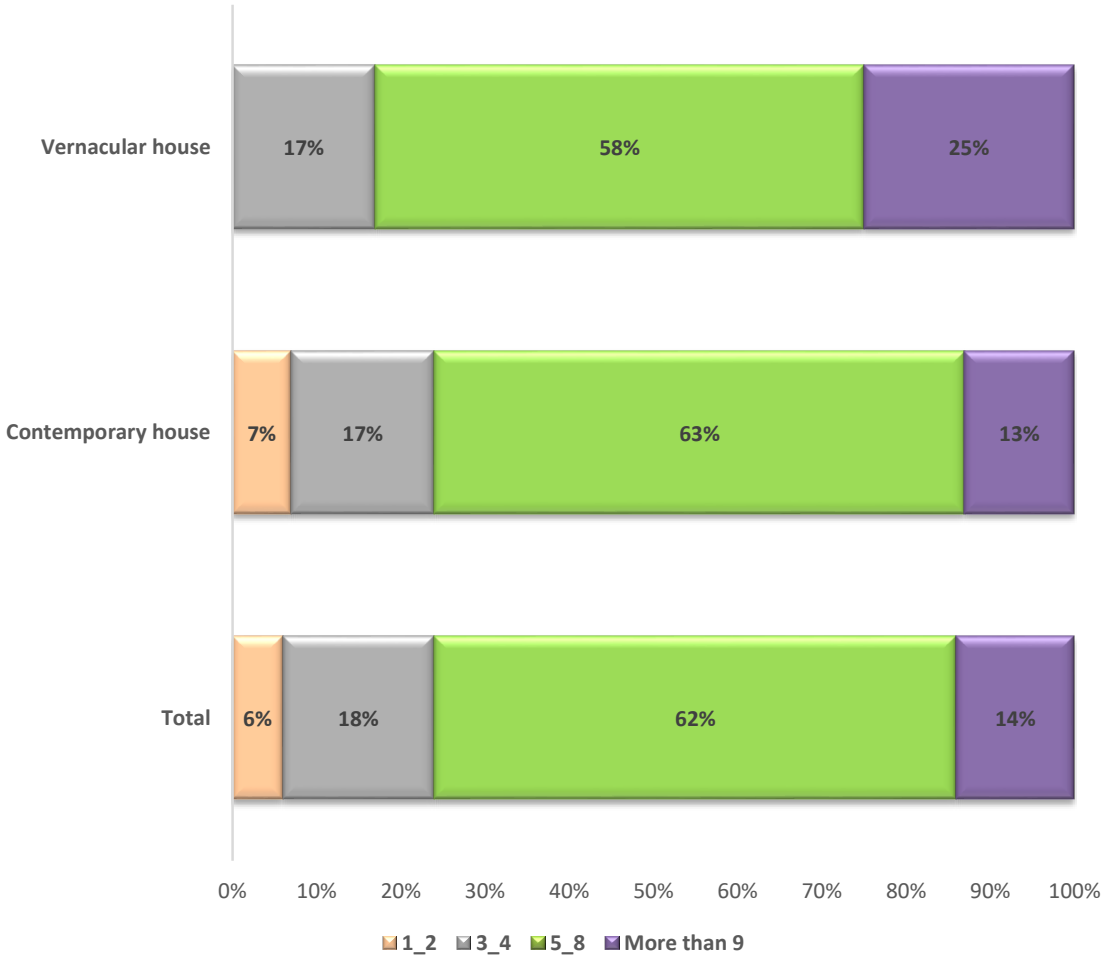


Figure 5.6: *Number within the family*

Table 5.3 and Figure 5.6 show the number of family members who live in the same house into four groups. The results show that 5-8 persons' households account for 62% (61/98) of family make up in both houses and that 3-4 persons' families and more than 9 people in a family account for less than 20% (17/98 (18%) and 14\98 (14%) respectively). Also, from Table 5.3 and Figure 5.6, it is apparent that most respondents lived in houses of 5-8 people reflecting the case that by tradition, Iraqi families are large (from personal experience). Families in Iraq tend to grow large due to economic hardships in the country. This means that families prefer to live in extended households involving several generations such as older couples, the sons and their families along with the unmarried daughters, all living under the same roof. Large occupant numbers, especially when gathering together in a living room, will be likely to contribute to increased indoor temperatures.

- **The period of living in dwellings**

All respondents (98) of vernacular house and contemporary house were asked the following question:

Q5: How long have you lived in your current home?	less than 5 years
	5-10 years
	11-20 years
	More than 20years

This question was asked for investigating total numbers of years living in the house.

Table 5.4: *The period of living in current house*

	Less than 5 years	5-10 years	11-20 years	More than 20 years	Total
Vernacular house	0	2	3	7	12
Percentage	0%	17%	25%	58%	12%
Contemporary house	11	15	42	18	86
Percentage	13%	17%	49%	21%	88%
Total	11	17	45	25	98
Percentage	11%	17%	46%	26%	100%

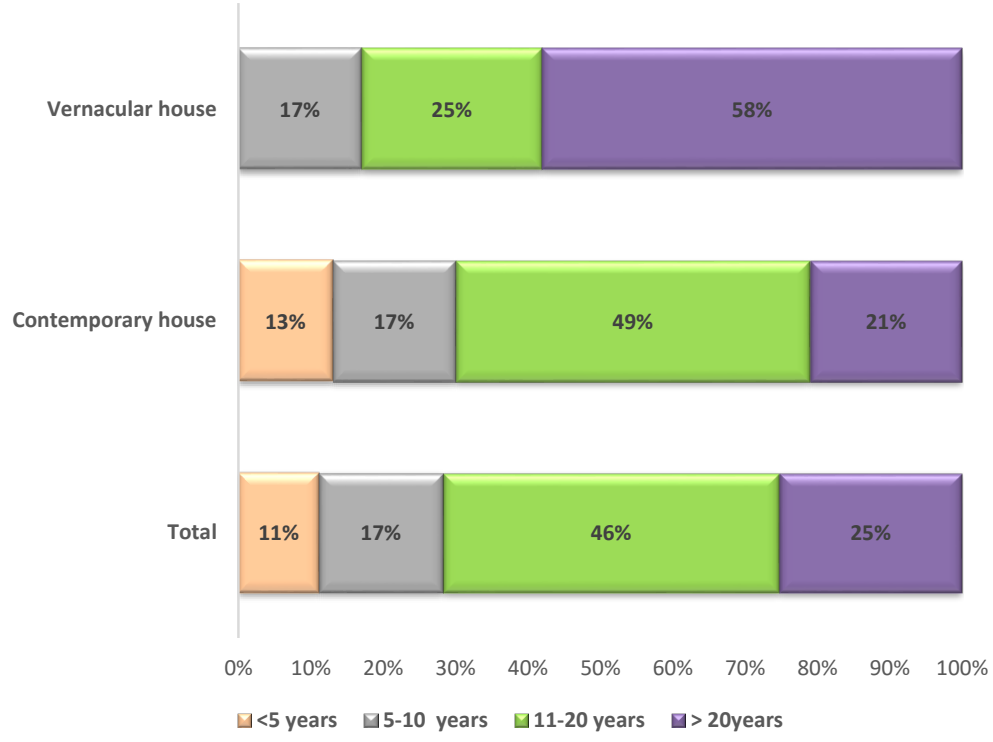


Figure 5.6: *The period of living in current house*

Table 5.4 and Figure 5.6 show that most (89%, 87/98) of the respondents have lived in their dwellings for more than 5 years. This shows that the respondents had a thorough knowledge of their houses and whether there were any problems in these dwellings.

5.2.2 Part B: Local domestic stock typology and current problems

The house situation: This section was included in order to gain more information on the dwelling situation. It was divided into four subsections: the first was to identify the type of tenure of houses the respondents currently live in, the second was to know the kind of houses the respondents currently use; the third was to know the floor area of the dwelling. Finally, was to know the satisfaction with the dwelling the respondents currently use.

- **Type of tenure**

All respondents (98) of vernacular house and contemporary house were asked the following question:

Q6: Are you the….. of your home?		Owner
		Tenants
		Living with family
		Other (provide details)

This question was asked to investigate the differences in the tenure types.

Table 5.5:*Type of tenure*

	Owners	**Tenants**	**Living with families**	**Others (Give details)**	**Total**
Vernacular house	2	6	4	0	12
Percentage	17%	50%	33%	0%	12%
Contemporary house	52	27	7	0	86
Percentage	60%	31%	8%	0%	88%
Total	54	33	11	0	98
Percentage	55%	34%	11%	0%	100%

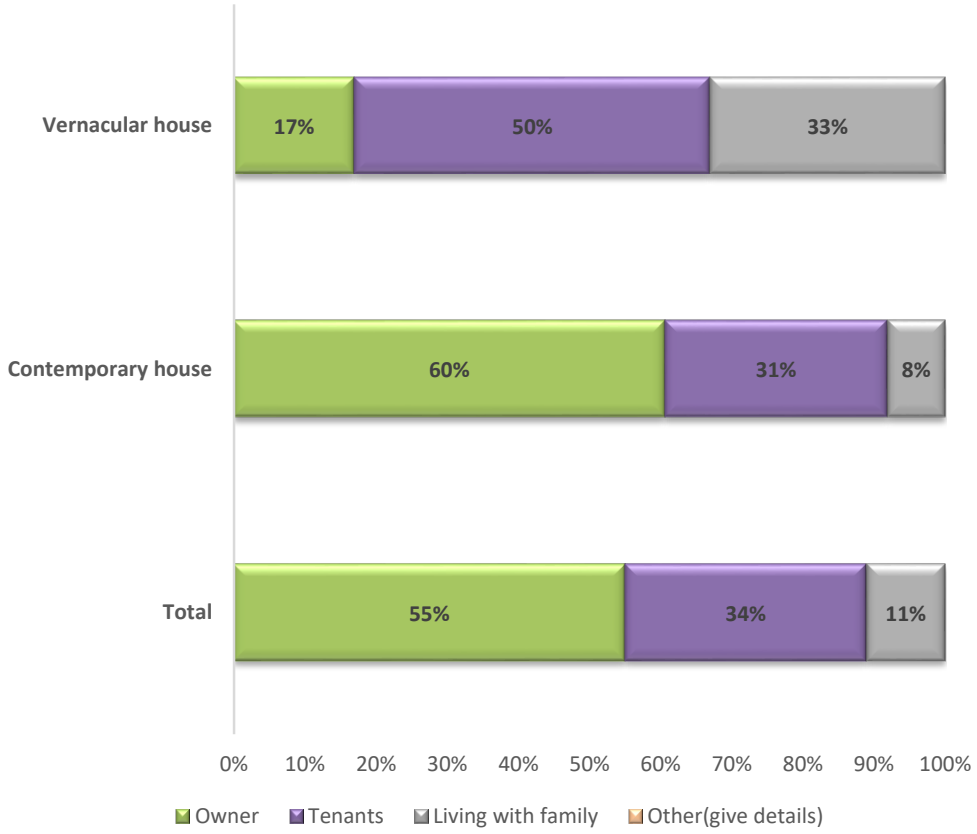


Figure 5.7: *Type of tenure*

In Table 5.5 and Figure 5.7, the type of tenure is classified into three groups, according to the dwelling tenure in Baghdad city. It shows that a high percentage of the total participants were owners 55% (54/98) of their houses, 34% (33/98) were tenants while 11% (11/98) were living with their wider families. The differences in the tenure types could help in providing different views of the residents' experience of living in their current dwellings.

- **The dwelling type**

All respondents (98) of vernacular house and contemporary house were asked the following questions:

Q7: What type of dwelling do you live in?	House
	Flat

This question was asked to investigate the kind of dwellings.

Table 5.6: *Types of respondents dwellings*

	House	Flats
Vernacular house	12	0
Percentage	12%	0%
Contemporary house	86	0
Percentage	88%	0%
Total	98	0
Percentage	100%	0%

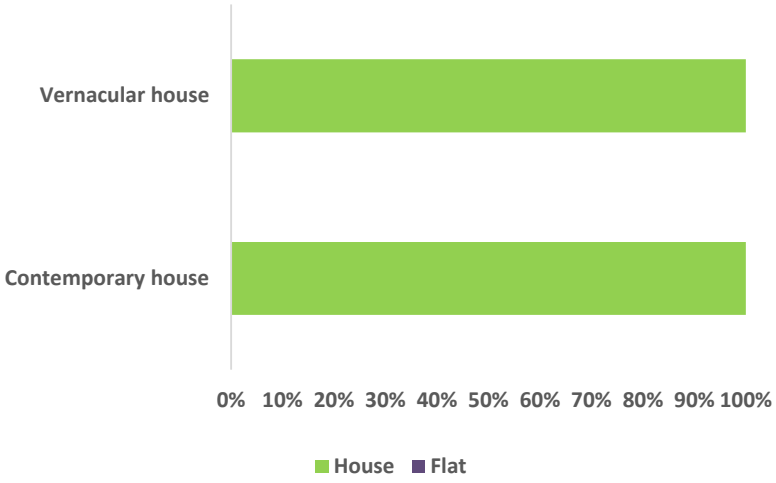


Figure 5.8: *Types of respondents' dwellings*

In Table 5.6 and Figure 5.8, the dwelling types are classified into two groups, according to the main dwelling typologies in Baghdad city. It shows that most of the residents live in houses where 88% (86/98) live in contemporary houses while 12% (12/98) live in vernacular houses, (Figure 5.8). This is also representative of Baghdad's lower percentage of properties which are flats while more than 67% of properties are houses (The Iraqi Ministry of Construction and Housing, 2016). Moreover, house-owners are over-represented in this survey in comparison to the Baghdad population; however, it is

appropriate to have a high proportion of house owners represented as the research is about houses rather than flats.

- **Floor areas of dwellings**

All respondents (98) of vernacular house and contemporary house were asked the following question:

Q8: What is the floor area of your home?		Less than 100 m²
		100-200 m²
		201-300 m²
		More than 300 m²

This question was asked to investigate the size floor areas of the dwellings.

Table 5.7: *Size of respondents dwellings*

	Less than100 m²	**100-200 m²**	**201-300 m²**	**More than 300 m²**	**Total**	**%**
Vernacular house	0	9	3	0	12	
Percentage	0%	75%	25%	0%		12%
Contemporary house	7	61	12	6	86	
Percentage	8%	71%	14%	7%		88%
Total	7	70	15	6	98	
Percentage	7%	71%	15%	7%	100%	

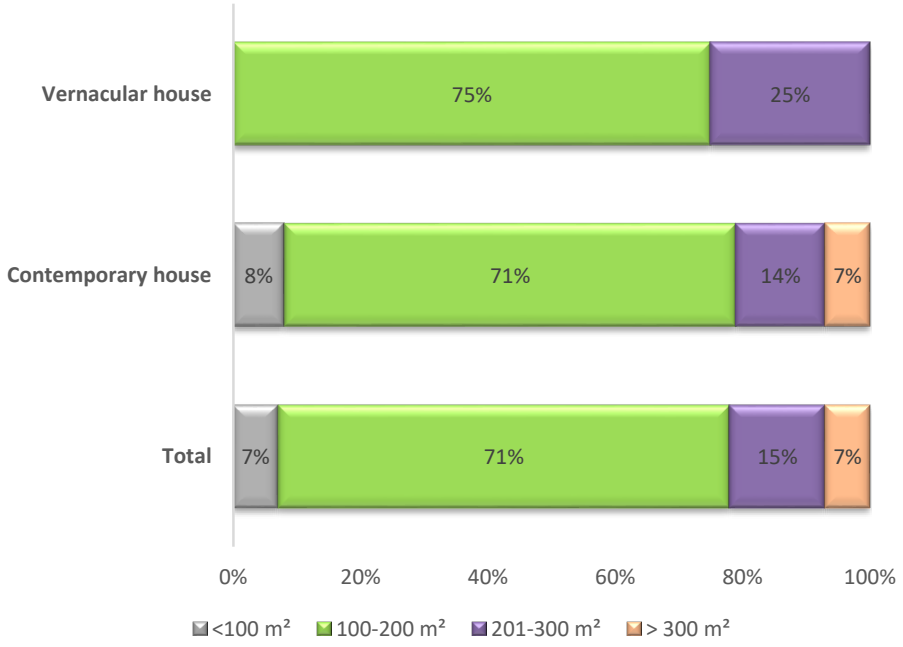


Figure 5.9: *Size of respondent's dwellings*

As illustrated from the results in Table 5.7 and Figure 5.9; 71% of the respondents (70/98) live in properties with an area of 100-200 m². On the other hand, about 7% (7/98) of the respondents live in properties with areas of less than 100 m², with a similar percentage (7%, 6/98) living in properties with more than 300 m² (Table 5.7 and Figure 5.9). Bigger houses area tends to use more electricity. The house size depends on inhabitant's numbers. As mentioned earlier, with the large occupant numbers, especially when gathering together in a living room, will be likely to contribute to increased indoor temperatures.

- **The level of satisfaction with the residence presently occupied by the participants**

All respondents (98) of vernacular house and contemporary house were asked the following question:

Q9: How satisfied are you with your home (in terms of meeting your households needs in the summer)?		Very satisfied
		Fairly satisfied
		Neither satisfied nor dissatisfied
		Fairly dissatisfied
		Very dissatisfied

This question was asked to investigate the respondents' satisfaction level with their houses and to discover which kind of house can provide better satisfaction levels for residences.

Table 5.8*: Respondents satisfactions with their house*

	Very satisfied	**Fairly satisfied**	**Neither satisfied nor dissatisfied**	**Fairly dissatisfied**	**Very dissatisfied**	**Total**	**%**
Vernacular house	1	10	1	0	0	12	12%
Percentage	8%	84%	8%	0%	0%	100%	
Contemporary house	0	42	3	41	0	86	88%
Percentage	0%	49%	3%	48%	0%	100%	

Total	1	49	4	44	0	98
Percentage	1%	50%	4%	45%	0%	100%

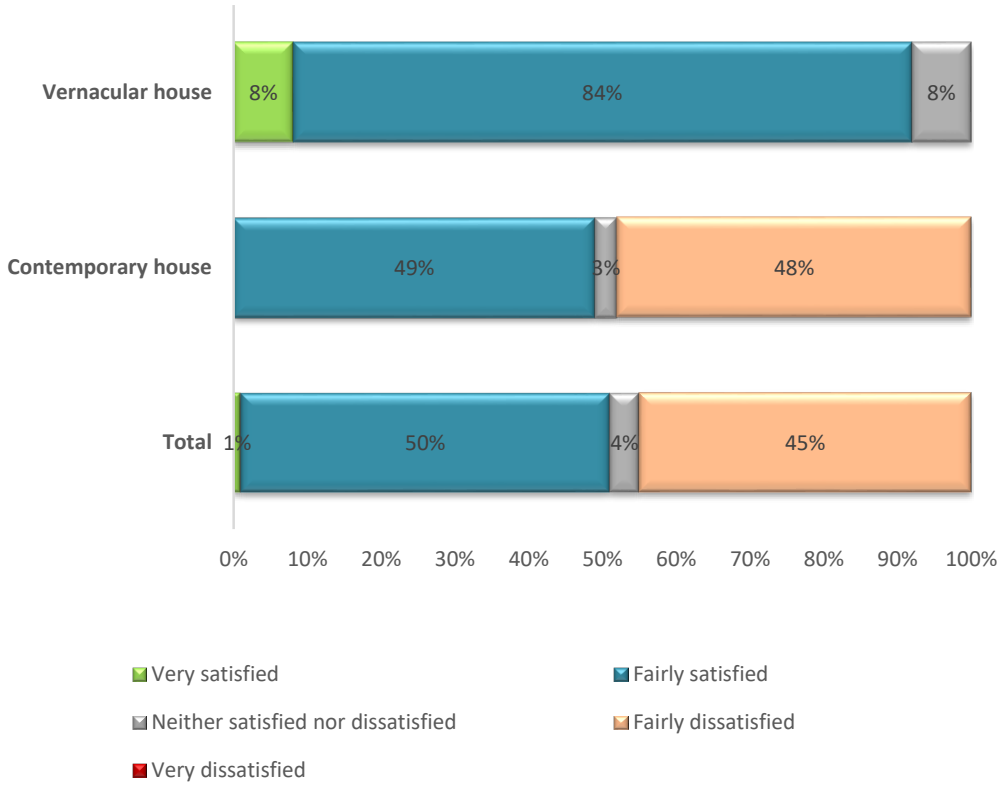


Figure 5.10: *Respondents satisfactions with their house*

Table 5.8 and Figure 5.10 show that 49% (42/86) of respondents in contemporary houses, were satisfied, in summer times, and the other 48% (41/86) were not. They indicate the reason for their choice depends on using air-condition or not. While, 84% (10/12) were satisfied and 8% (1/98) of the respondents in vernacular house, were very satisfied with their homes, in summer times, and the rest were neither satisfied nor dissatisfied. These results confirm the importance of the vernacular house in providing satisfaction and a pleasant indoor thermal comfort.

5.2.3 Part C: Patterns of energy consumption

Through an in-depth analysis of public perceptions of their energy consumptions behaviours, a number of key factors identified regarding the unusually high energy consumption rates in the residential sectors of Baghdad. The factors were identified by

presenting a series of questions to ascertain what is causing increased consumption of energy trends in the housing sectors of Baghdad, as shown below:

- **The average hours per day of occupancy**

All respondents (98) of vernacular house and contemporary house were asked the following question:

Q10: How long is your house occupied per day on average(not include of sleep hours?	Less or equal than 3 hours/day
	4-6 hours/day
	6-10 hours/day
	Greater than 10 hours/day

This question was presented to identify for how many hours the dwelling is occupied per day.

Table 5.9 : *Normal duration for homes to be occupied*

	Less or equal than 3 hours/day	4 -6 hours/day	6-10 hours/day	Greater than 10 hours/day	Total
Vernacular house	0	1	6	5	12
Percentage	0%	8%	50%	42%	
Contemporary house	2	15	27	42	86
Percentage	2%	17%	31%	49%	
Total	2	16	33	47	98
Percentage	2%	16%	34%	48%	100%

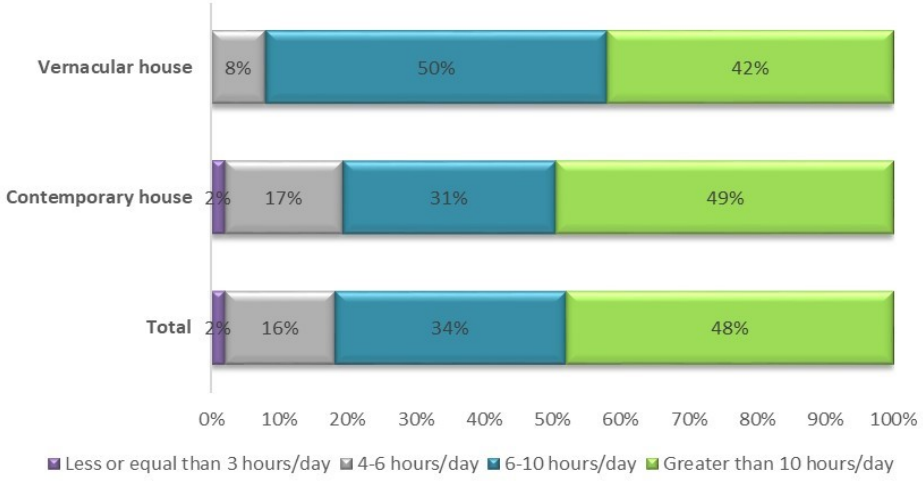


Figure 5.11: *Normal duration for homes to be occupied*

The results in Table 5.9 and Figure 5.11 demonstrate that most homes are occupied for long periods (6 hours or more) per day (82%, 80/98).

Occupied homes tend to use more electricity and their electricity usage varies significantly from day to day than in unoccupied homes. Table 5.9 and Figure 5.11 show the average hours of occupancy per day. It can be noted that occupancy is 6 hours or more per day (82%, 81/98). The period of the occupancy resulted in higher electricity consumption and higher variability in day to day consumption.

- **Using air-conditioning**

All respondents (98) of vernacular house and contemporary house were asked the following question:

Q11	A: Is it important to use air conditioning in your house?		Yes
			No
	B: Which areas of the house are supported by the air conditioning?		In all rooms
			In the majority rooms
			In some rooms
	C: How often do you use the air-conditioning?		All the year
			All summer time
			When the temperature is very high
			When the temperature is very low
	D: How many hours per day is the air conditioner used during summer times?		Less than5 hours per day
			5-10
			10-15
			15-20
			Over than20 hours per day

This question was asked in order to investigate to what extent the residents depended on using air conditioning to achieve internal thermal comfort. It was divided into four subsections. The first section was to discover the percentage of the respondents using air conditioning to provide thermal comfort in their houses; the second section was used to discover the place of using the air conditioning in both house, and the third section was used to find out how often was the air-conditioning used for. Finally, it was aimed to find out how long a period of time the respondents use air conditioning.

Table 5.10: *Using air conditioning*

	Yes	No	Total	%
Vernacular house	1	11	12	12%
Percentage	8%	92%	100%	
Contemporary house	58	28	86	88%
Percentage	67%	33%	100%	
Total	59	39	98	
Percentage	60%	40%	100%	

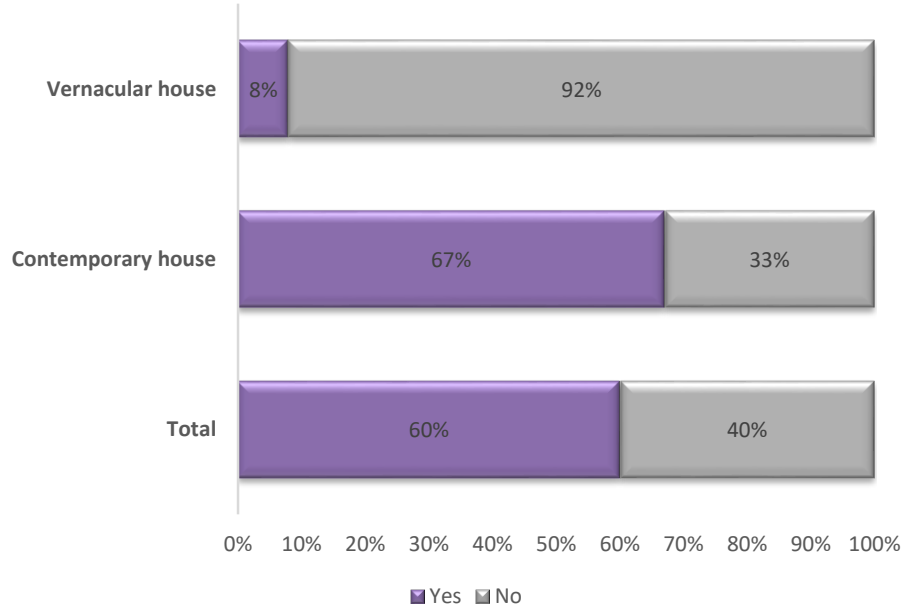


Figure 5.12: *Using air conditioning*

Table 5.1o and Figure 5.12 show that 67% (58/86) of respondents in contemporary housing use air-conditioning units and 33% (28/86) of them do not use it. While, only 8% (1/12) of respondents in vernacular housing use air-conditioning units and 92% (11/12) of them do not use it. The result show that in contemporary houses, the participants do not feel comfortable in their houses without using air-conditioning units. That is due to the lack of passive design techniques and also they do not have a good response to climate conditions.

Table 5.11 and Figure 5.13 show the place of using air-condition.

Table 5.11: *Place of using air conditioning*

	In all rooms	In the majority rooms	In some rooms	Total
Vernacular house	0	0	1	1
Percentage	0%	0%	100%	100%
Contemporary house	8	32	18	58
Percentage	14%	55%	31%	100%
Total	8	32	19	59
Percentage	14%	55%	32%	100%

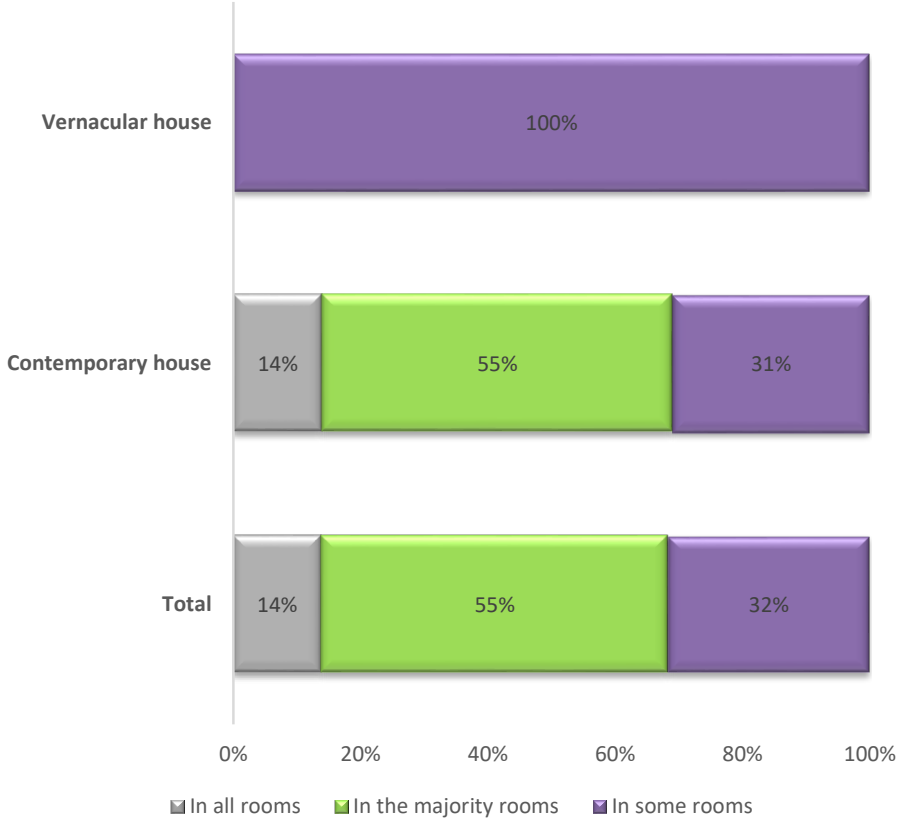


Figure 5.13: *Place of using air conditioning*

Table 5.12 and Figure 5.14 show the place of using air-condition.

Table 5.12: *Time of using air conditioning(annual)*

	All the year	All summer time	When the temperature is very high	When the temperature is very low	Total
Vernacular house	0	0	1	0	1
Percentage	0%	0%	100%	0%	100%
Contemporary house	5	32	18	3	58
Percentage	9%	55%	31%	5%	100%
Total	5	32	19	3	59
Percentage	8%	54%	33%	5%	100%

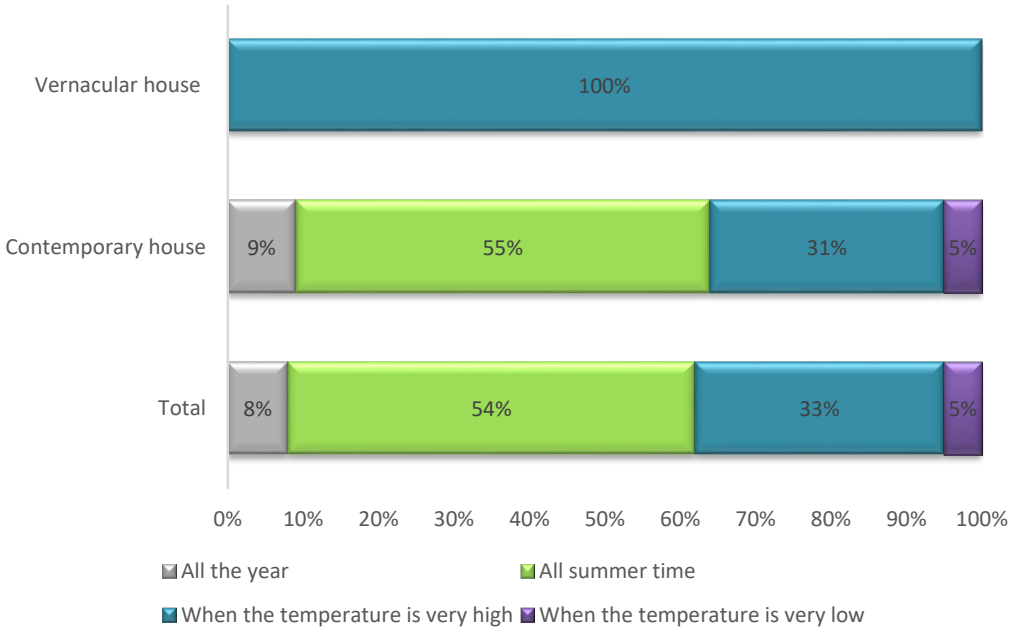


Figure 5.14: *Time of using air conditioning(annual)*

Table 5.12 and Figure 5.14 show that 67%(58/86) of people in contemporary housing make use of air conditioning and 33% (28/86) of them do not use it. While only 8%(1/12) in vernacular house use air-condition. As illustrated in Table 5.13 and Figure 5.15, 55%

(32/59) of those who use air conditioning use it in the majority of the rooms and 31% (18/58) use it in some rooms. Also, 55% (32/59) of the respondents use air conditioning in the summer-time and 33% (19/59) of them use air conditioning when the temperature is very high (Table 5.12 and Figure 5.14). These results indicate that using air conditioning in vernacular houses is not felt to be as important as using it in the contemporary houses where it is needed to achieve internal thermal comfort. This confirms the need for using passive design techniques in houses in the future in order to reduce dependency on air conditioning.

Table 5.13: *Average period per day of using air-conditioning in home*

	Less than 5 hours per	5-10 hours per day	10-15 hours per day	15-20 hours per day	Over than 20 hours per day	Total
Contemporary house	0	0	1	0	0	1
Percentage	0%	0%	100%	0%	0%	100%
Vernacular house	1	11	18	16	12	58
Percentage	2%	19%	31%	28%	20%	100%
Total	1	11	19	16	12	59
Percentage	2%	19%	32%	27%	20%	100%

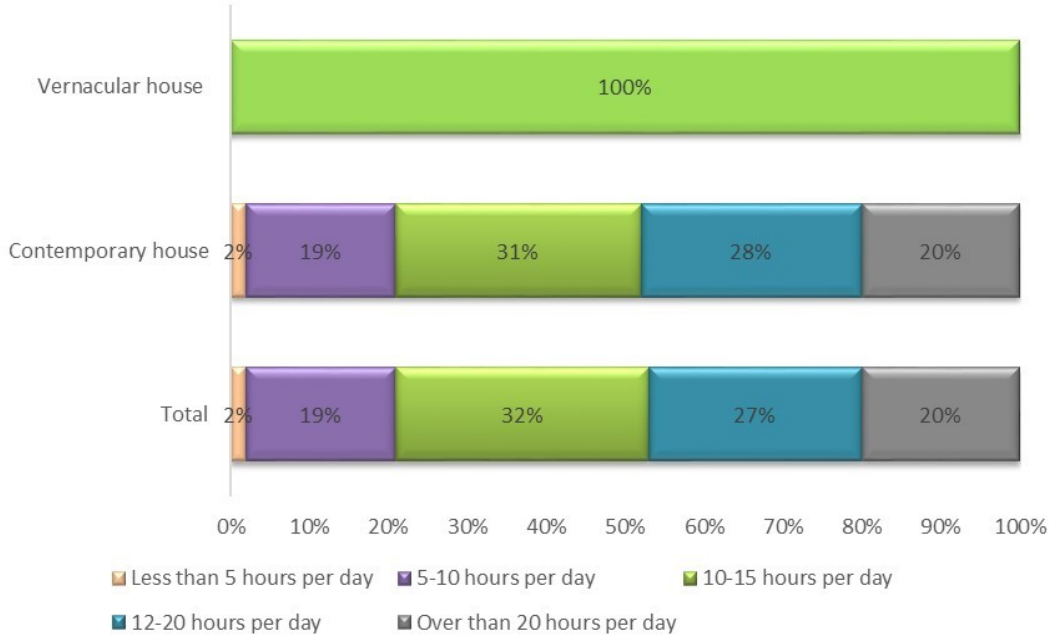


Figure 5.15: *Average period per day of using air-conditioning in home*

As mentioned before in Table 5.9 and Figure 5.11, most homes are occupied for long periods (6 hours or even more) per day. Table 5.13 and Figure 5.15 show the period of using air conditioning in the houses during the year, while Table 5.15 and Figure 5.17 show the period in daytime. In months of hot summer, 80%(51/59) of the respondents are used air-condition between 10-24 hours and this reflects the high kWh are used in hot summer. Also, 86% (50/58) of the residents in contemporary houses who use air conditioning use it in the summer time when the temperature is very high These results indicate that using air conditioning in vernacular houses is not felt to be as important as using it in the contemporary houses where it is needed to achieve internal thermal comfort levels. This confirms the need for using passive design techniques in houses in the future in order to reduce dependency on air conditioning.

- **Respondents' opinions on how to tackle high temperatures**

All respondents (98) of vernacular house and contemporary house were asked the following question:

Q12: If electricity is off what will you do to escape a high temperature?		Open windows to promote cross ventilation
		visit a family that have an air conditioner
		Sit in the garden (or courtyard)
		Go to do shopping
		Other (please specify)

This question was to investigate respondents' solutions on how to tackle high temperatures in cases where air conditioning was not used or during generator hours. The respondents gave the suggestions reported in Table 5.14 and Figure 5.16. 78% (76/98) of the respondents chose to open windows to get cross currents of air; this indicates the importance of adequate designing of dwellings to allow suitable air movement. This indicates the importance of the windows' location and size in achieving suitable air movements.

Table 5.14: *Solution for tackling high temperatures*

	Open windows to get cross air	visit a family that have an air conditioner	Sit in the garden (or courtyard)	Go to do shopping	Others	Total	%
Vernacular house	10	0	0	2	0	12	12%
Percentage	83%	0%	0%	17%	0%	100%	
Contemporary house	66	1	16	3	0	86	88%
Percentage	76%	1%	19%	4%	0%	100%	
Total	76	1	16	5	0	98	
Ppercentage	78%	1%	16%	5%	0%	100%	

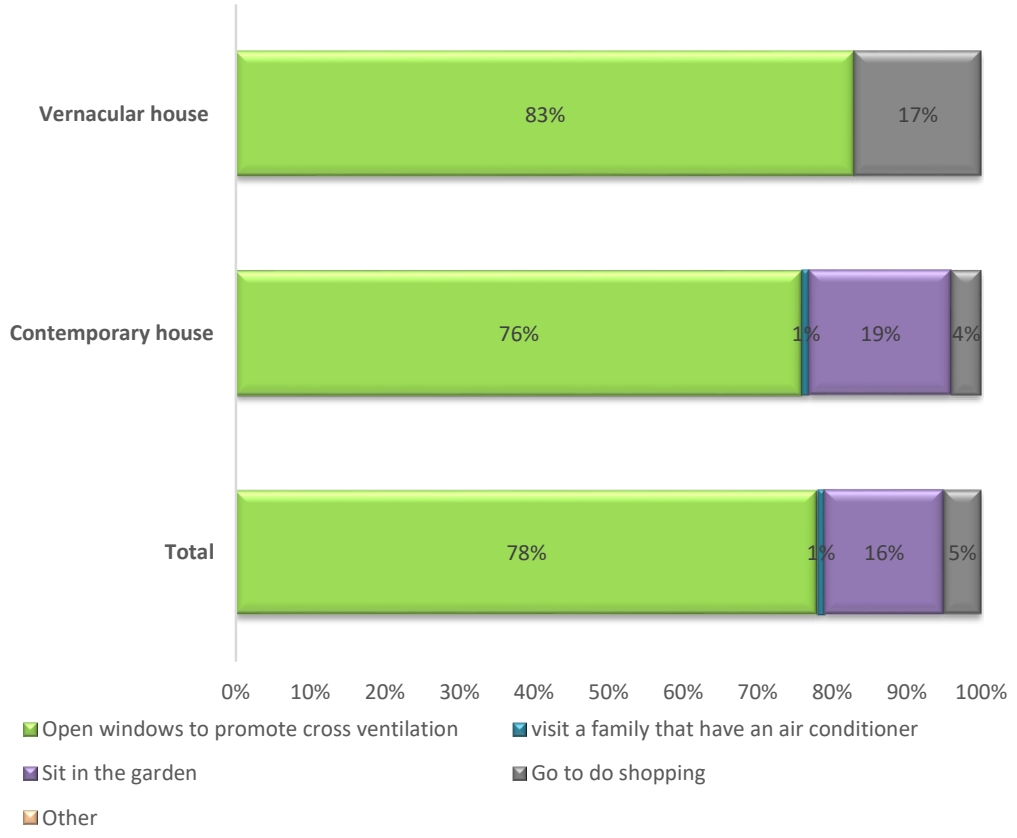


Fig 5.16: *Solution for tackling high temperatures*

5.2.4 Part D: Public perception and knowledge about vernacular design and contemporary design

This section presents the analysis of the respondents (98) to find out their opinion on what exactly about vernacular design is valued and appreciated and what are perceived barriers in its contemporary application.

- **Opinion on vernacular design and its suitability with current requirements**

All respondents (98) of vernacular house and contemporary house were asked the following question:

Q13: How would you describe the vernacular Iraqi design? What's are its key features?	Please write your answer below.

This question intended to understand respondents' perceptions and attitudes towards vernacular architecture design. It states, how would you describe the vernacular Iraqi design? What are its key features? The open-ended nature of this question was chosen to not only elicit the most prevalent elements but also gain deeper insights into the meanings behind how people associate these design elements with socio-cultural understandings. As a result, the participants provided rich descriptions of how they perceived the vernacular architecture design.

Table 5. 15: *Describing the vernacular Iraqi architecture: frequency and percentage of the maximum recognized vernacular components by respondents*

Vernacular Element	Courtyard	Shanasheel	Bagdir	Mud/Clay Bricks	Façade -wooden doors/windows	Total	%
Vernacular house	4	3	2	1	2	12	12%
Percentage	33%	25%	17%	8%	17%		
Contemporary house	56	16	10	3	1	86	88%
Percentage	65%	19%	12%	3%	1%		
Total	60	19	12	4	3	98	
Percentage	61%	20%	12%	4%	3%	100%	

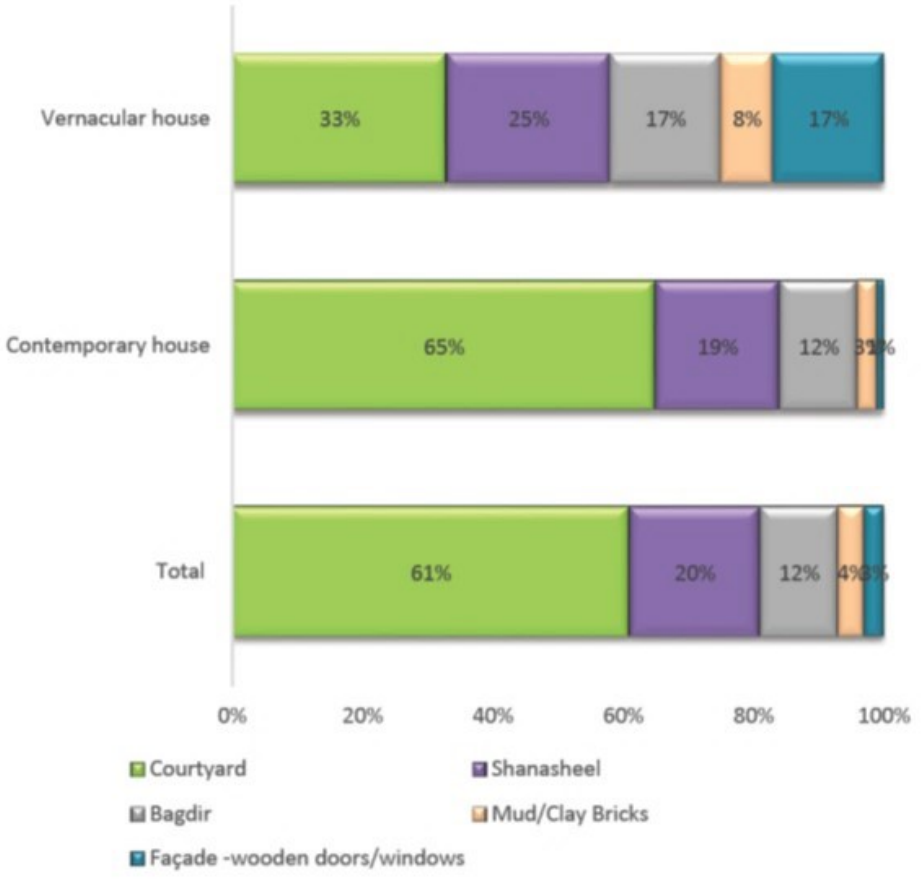


Figure 5. 17: *Describing the vernacular Iraqi architecture: frequency and percentage of the maximum recognized vernacular components by respondents.*

Table 5.15 and Figure 5.17 show the most identified vernacular elements when describing the vernacular Iraqi architecture. Figure 5.17 shows the top five most identified traditional vernacular elements by the participants when describing the vernacular Iraqi architecture. The courtyard appeared most frequently, appearing in 60/98 (61%) of all participants' responses, followed by shanasheel, bagdir, mud bricks, and Façade –wooden doors/windows. The results show that the courtyard is by far the most recognized element. A percentage of the elements are shown in Table 5.15.

The further content analysis generated categories of the different ways participants expressed vernacular architecture. The responses were grouped into two broad categories; the first was environmental aspects, and the second was social/cultural aspects. Table 5.16 below presents categories derived from participants' descriptions of the vernacular Iraqi architecture.

Table 5.16: *Describing the vernacular Iraqi architecture: Shows broad categories and percentages by respondents*

key functional aspects	Sociocultural aspects	Environmental aspects	Total	%
Vernacular house	10	2	12	12%
Percentage	83%	17%		
Contemporary house	37	49	86	88%
Percentage	38%	50%		
Total	47	51	98	
Percentage	48%	52%	100%	

Table 5.16 shows that 83% (10/12) of respondents in vernacular housing associate vernacular architecture with socio-cultural aspects and 17% (2/12) of them associate the vernacular architecture with environmental aspects. While only 38% (37/86) of respondents in contemporary housing associate the vernacular architecture with and 50% (49/86) of them associate the vernacular architecture with environmental aspects. The results show that in vernacular houses, the socio-cultural aspects appear most frequently in participants' responses. Despite, in contemporary houses, the environmental aspects appeared the most frequent possibility.

As show in Table 5.16 the responses classified into two broad categories; the environmental and the social/cultural aspects. Each category includes subcategories as below.

Sociocultural aspects

- Direct/extended family and neighborhood bonds;
- Built to provide basic needs (shelter/comfort, food& water storage, privacy, accessibility);
- Design of adjacent houses built to strengthen Social.

Environmental aspects

- Observed for a long time and have proved their suitability to the climate;
- Optimal designs (ventilation, heat management, size of windows, elevations, orientation);
- Green building/Sustainable;
- Courtyard houses usually feature an internal garden consisting of trees and a fountain that helps to regulate internal temperatures;
- Compact forms help to reduce direct heat gains where narrow streets increase shading and most surfaces are protected from the direct sun.

- **Percentage of people that want a vernacular feature in their current or future house**

All respondents (98) of vernacular house and contemporary house were asked the following question:

Q14: Assuming there were no practical or financial barriers, would you like to include vernacular features (such as courtyard..etc.) or techniques in your current or future house?	(Please tick one)	
		Yes, Go to question 15
		No

This question was intended to see how much representative recognition and desire for the vernacular features (such as courtyard…. etc.) was in the first stage of the study.

Table 5.17: *Percentage of people that want a vernacular features in their current or future house*

	Yes	**No**	**Total**	**%**
Vernacular house	10	2	12	12%
Percentage	83%	17%		
Contemporary house	77	9	86	88%
Percentage	90%	10%		
Total	87	11	98	
Percentage	89%	11%	100%	

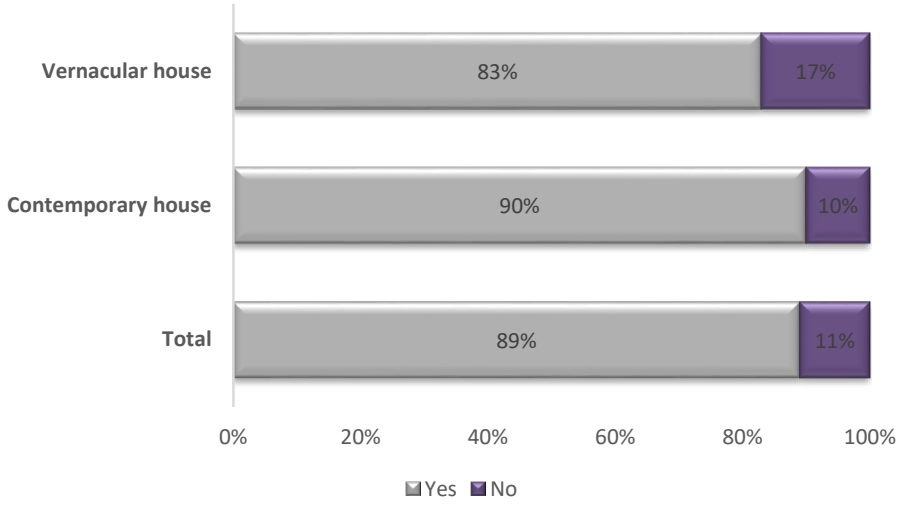


Figure 5.18: *Percentage of people that want a vernacular features in their current or future house*

Table 5.17 and Figure 5.18 show that an overwhelming majority of the participants, i.e. 89 % (87/98), desire vernacular features (such as courtyard) in their current or future homes. This means that the respondents are likely to accept the final design strategies where solutions will be suggested that include both vernacular architecture and passive solutions.

- **Primary motive for adding vernacular features (such as courtyard…etc.)**

All respondents (98) of vernacular house and contemporary house were asked the following question:

Q 15	If yes (Q14) what is your primary motive for adding a vernacular features or elements?	(Please tick one)	
			Expresses culture/identity
			Environmental aspects
			Aesthetic qualities
			Other (please specify)

Table 5.18: *Reasons for implementing vernacular features*

	Expresses culture/identity	Environmental aspects	Aesthetic qualities	Other	Total	%
Vernacular house	4	5	1	0	10/12	
Percentage	40%	50%	10%	0%		
Contemporary house	17	37	5	18	77/86	
Percentage	22%	48%	6%	24%	100%	
Total	21	42	6	18	87/98	
Percentage	24%	48%	7%	21%	100%	

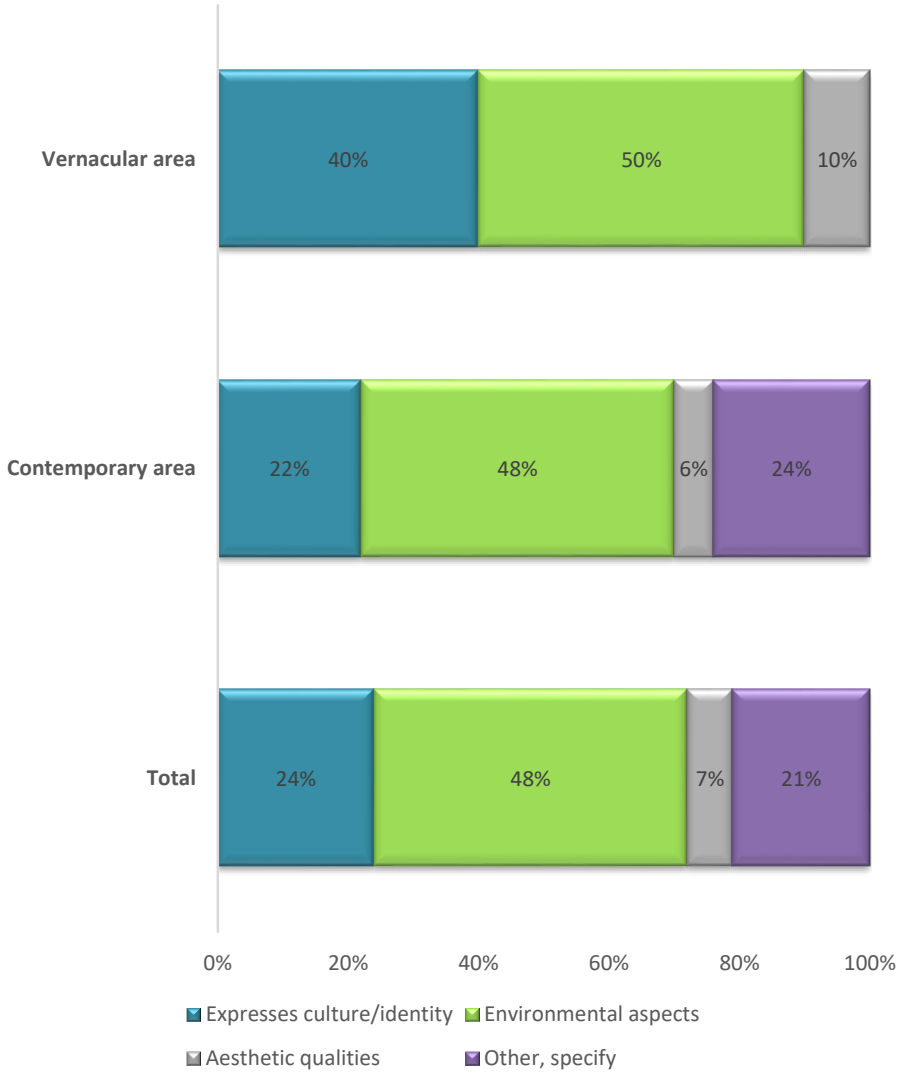


Figure 5.19: *Reasons for implementing vernacular features*

As shown in Table 5.18 and Figure 5.19, environmental aspects were recognised to be the most common motive by 48 % (42/87) of respondents (who answer yes in Q15). 24% (21/87) mentioned culture and identity while about 6% (7/87) stated aesthetic and qualities as the motive. 21% (18/87) of the respondent's choice others and mentioned that all options motive them. Therefore, it can be stated that the analysis of the data obtained from this question shows the mix of different features recognised by respondents in choosing motives for implementing vernacular features.

- **The most valued qualities in vernacular features**

All respondents (98) of vernacular house and contemporary house were asked the following question:

Q16	What are the most valued as well as appealing qualities that you associate with the vernacular design features (such as courtyard).	(Please tick one or more of the boxes below)	
			Privacy
			Its form and shape
			Tranquillity, quiet, calm and relaxation
			Spaciousness, openness to the sky
			Protection and security from streets
			Use of green spaces, plants, shrubs, trees, and so on.
			Cooling and natural ventilation
			Natural sunlight in the houses
			Social space and stronger family ties
			Identity, self-expression
			Others, please indicate

This question was an extension of question 15 in that it also attempted to further understand people's motives for adding a vernacular feature by examining the qualities that they value in the vernacular features.

Table 5.20: *Vernacular features qualities which are valued*

	Privacy	**Its form and shape**	**Tranquillity, quiet, calm and relaxation**	**Spaciousness, openness to the sky**	**Protection and security from streets**	**Use of green spaces, plants, shrubs, trees, and so on.**	**Cooling and natural ventilation**	**Natural sunlight in the houses**	**Social space and stronger family ties**	**Identity, self-expression**	***Others, please indicate**	**Total**
Vernacular house	3	0	0	0	2	2	1	1	2	1	0	12
percentage	3%	0%	0%	0%	2%	2%	1%	1%	2%	1%	0%	
Contemporary house	11	0	6	9	5	18	5	4	22	2	4	86
percentage	11%	0%	6%	9%	5%	19%	5%	4%	22%	2%	4%	
Total	14	0	6	9	7	20	6	5	24	3	4	98
percentage	14%	0%	6%	9%	7%	21%	6%	5%	25%	3%	4%	100%

** The participants identified all options as the most valued qualities of vernacular features*

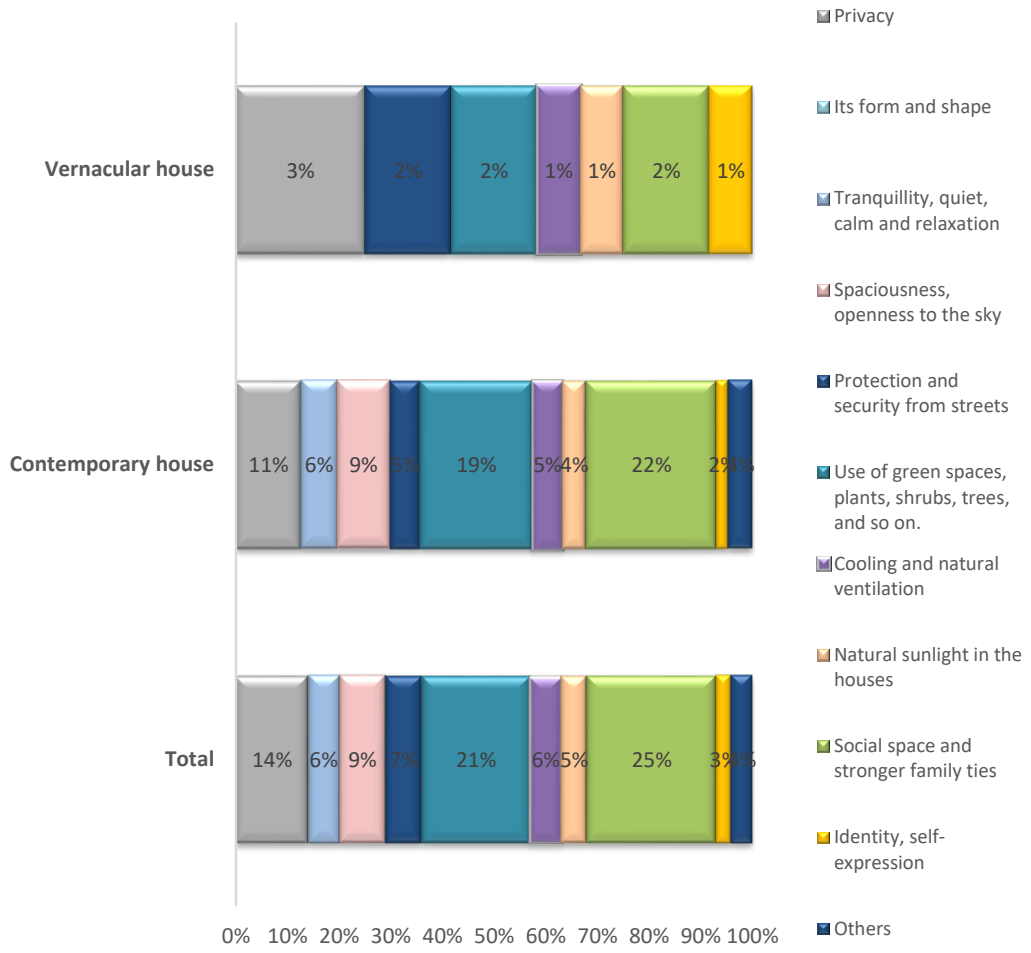


Figure 5.21: *The participants valued many qualities in vernacular features*

The results obtained in this question aligned well with question 16's results. To elaborate, the results suggested that the environmental as well cultural qualities are deemed significant by respondents. In fact, 25% (24/98) of the respondents indicated that strong family ties as well as social spaces are the highly desirable qualities of vernacular features. In terms of other potential qualities, about 21% (20/98) identified green spaces, 14% (14/98) recognised privacy, 9% (9/98) identified spaciousness and openness, 6% (6/98) identified relaxation, calmness and tranquillity, 5% (5/98) identified natural sunlight, 7% (7/98) identified security and protection, 6% (6/98) identified cooling and natural ventilation, 4% (4/98) identified other qualities and 3% (3/98) identified identity and self-expression. Table 5.20 demonstrates the frequency versus percentage breakdown. Figure 5.21 demonstrates the choices of respondents.

- **Barriers and limitations experienced by residents in adopting vernacular features.**

  All respondents (98) of vernacular house and contemporary house were asked the following question:

Q.17	To what extent would you agree or not with the following issues that may prevent you from adding a courtyard in your current or future house?					
	(Please tick the appropriate box)	Strongly agree	Agree	Neutral	Disagree	Strongly disagree
	Having a small plot of land					
	It reminds you of vernacular houses					
	Cultural changes from Iraqi's transformation					
	Lack of government regulation to promote courtyards					
	High real-estate prices					
	Scarcity of residential Land					
	Iraqi's housing crisis					

Table 5.21 and Figure 5.22 show the potential barriers to the use of courtyards.

Table 5.21: *Potential barriers to the use of courtyards*

	Strongly agree	Agree	Neutral	Disagree	Strongly disagree
Possession of small lands	65	22	9	1	1
Percentage	66%	23%	9%	1%	1%
Resemblance to vernacular designs	6	2	17	34	39
Percentage	6%	2%	17%	35%	40%
Social transformation in terms of Iraq's culture	1	3	21	42	31
Percentage	1%	3%	21%	43%	32%
Absence of governmental regulations	27	31	33	4	3
Percentage	27%	32%	34%	4%	3%
Increased real estate costs	74	16	5	2	1
Percentage	75%	17%	5%	2%	1%
Lack of residential lands	57	17	16	5	3
Percentage	58%	18%	16%	5%	3%
Iraq's housing crisis	52	31	14	0	1
Percentage	53%	32%	14%	0%	1%

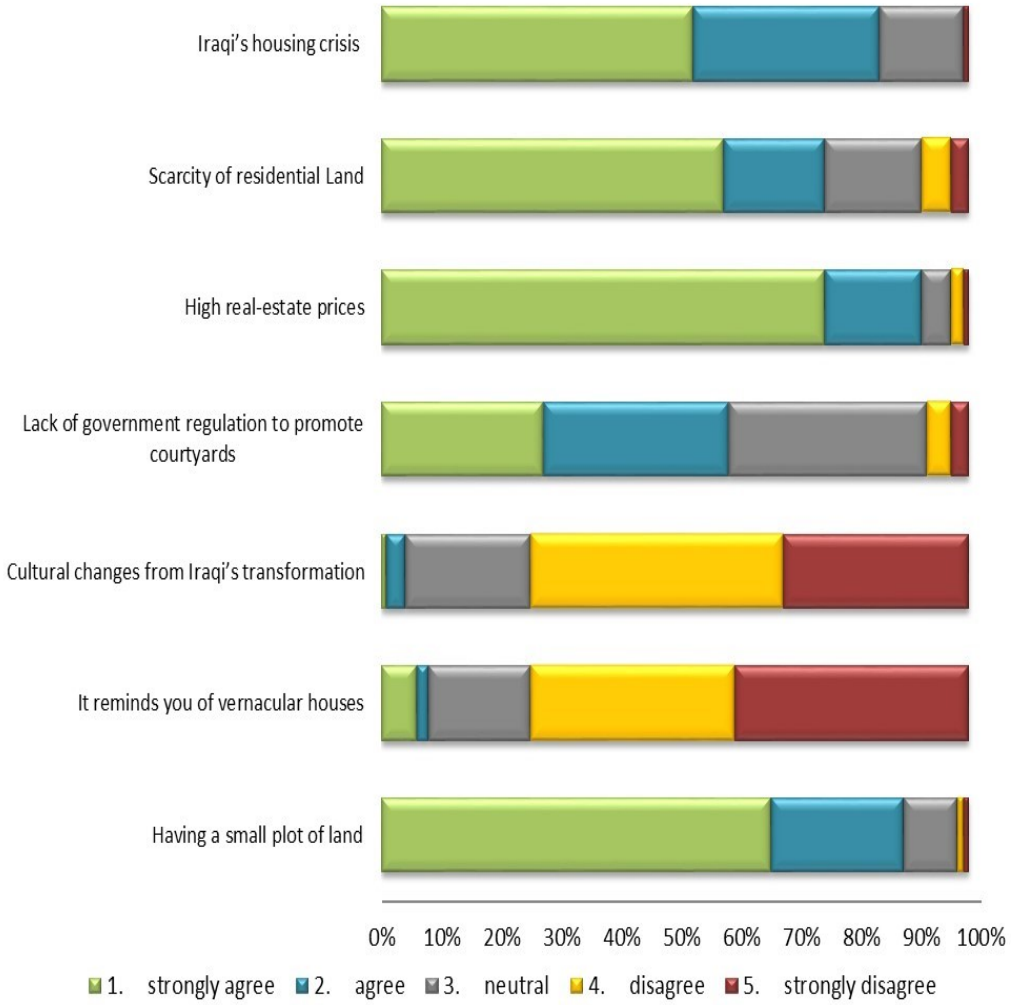


Figure 5.22: *Potential barriers to the use of courtyards*

Table 5.21 and Figure 5.22 show that 92% (90/98) of the respondents agreed strongly that they prefer not to use a courtyard due to the very high prices for existing real estate. Iraq's housing crisis with 85% of respondents who strongly agreed (53%,52/98) or agreed (32%,31,98), scarcity of residential land with 76% (74/98) of respondents who strongly agreed (58%,57/98) or agreed (18%,17/98), and the scarcity and ineffectiveness of government regulations to promote the use of with 59% (58/98) of respondents who strongly agreed (27%,27/98) or agreed (32%,31/98). The housing crisis in Iraq was stated by most respondents to be the primary reason that discourages people from using or building courtyards in their current or future residential spaces.

- **Preferred types of houses**

All respondents (98) of vernacular house and contemporary house were asked the following question**:**

Q.17	What kind of houses do you prefer to live in? Why?		Vernacular houses
			Contemporary houses
			Contemporary houses with vernacular style
			new houses which combined (vernacular+ Contemporary+ technology)

Respondents were asked to choose what kind of houses they preferred from the options of "vernacular house", "contemporary house", "contemporary house with vernacular style", new house with combined vernacular and contemporary technology".

Table 5.22: *Preferred type of houses*

	New houses which combined(vernacular+ Contemporary + technology	**Contemporary houses with vernacular style**	**Contemporary houses**	**Vernacular houses**	**Total**	**%**
Vernacular house	8	1	2	1	12	12%
Percentage	67%	8%	17%	8%		
Contemporary house	73	10	3	0	86	88%
Percentage	85%	12%	3%	0%		
Total	82	11	5	1	98	
Percentage	83%	11%	5%	1%	100%	

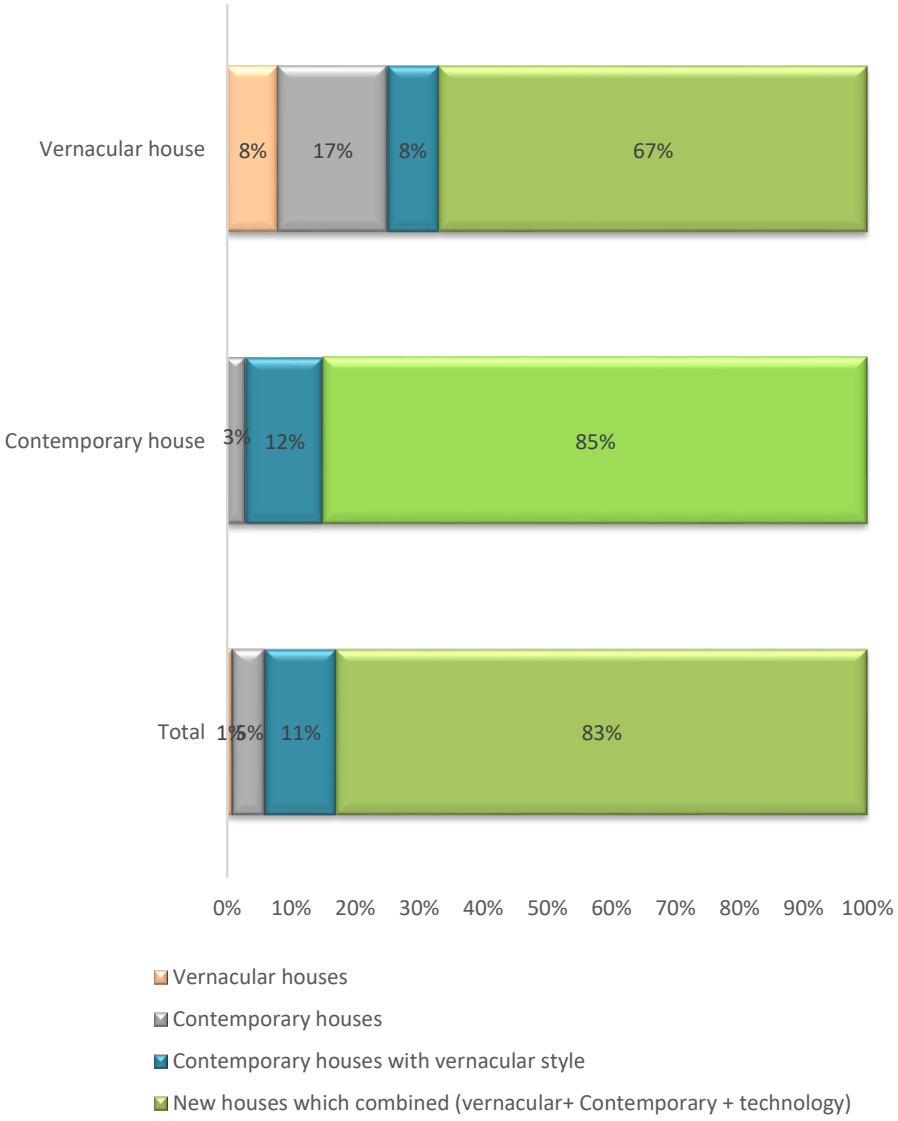


Figure 5.23: *Preferred type of houses*

Table 5.22 and Figure 5.23 show that 84% (83/98) preferred to live in modern houses with vernacular design as an option to use in contemporary technology. Although only 1% of respondents preferred to live in a truly vernacular house, a further 12% (11/98) were willing to live in houses with vernacular features/styling. Only3% (3/98) preferred to live in wholly contemporary houses. This shows that people do like the advantages of contemporary and vernacular types of housing. This means that the respondents are likely to accept the final guidelines where solutions will be suggested that include both vernacular architecture and passive solutions.

5.2.5 Part E: Public information and knowledge of highly efficient modern homes

This section presents the analysis of the respondents (98) to find out their opinion on what exactly about the knowledge of low energy homes.

- **Sustainable, low energy house**

All respondents (98) of vernacular house and contemporary house were asked the following question:

Q19	A: Do you understand the concepts of sustainable, low energy or green building?	Please tick the appropriate box	
			Yes, Go to question B and C
			No
			I don't know
	B: If yes (A), please indicate the sources of your understanding?		Internet
			Media
			News
			TV
			Experiences
			Advertising
			Others
	C: If your answer (A) is yes, do you think that houses that incorporate these features are more expensive than other houses?		More expensive
			Less expensive
		Please explain your answer below	

This question was designed to investigate the respondent's knowledge of low energy houses. It was divided into two subsections. The first subsection was to find out the percentage of those respondents who have an understanding of low energy houses, and the second subsection concerned the expense of producing these kinds of houses.

Table 5.23: *knowledge concerning low energy house*

	Yes	No	I don't know	Total	%
Vernacular house	2	10	0	12	12%
Percentage	17%	83%	0%	100%	
Contemporary house	49	37	0	86	88%
Percentage	57%	43%	0%	100%	
Total	51	47	0	98	
Percentage	52%	48%	0%	100%	

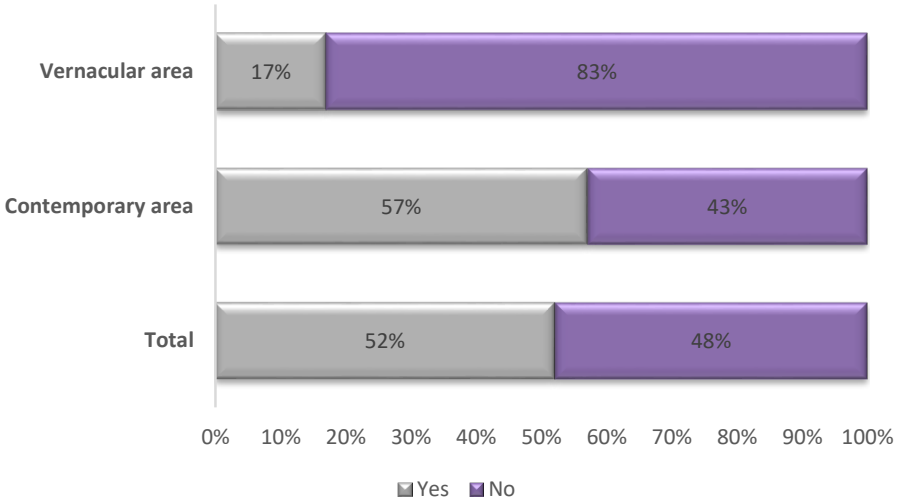


Figure 5.24: *knowledge concerning low energy house*

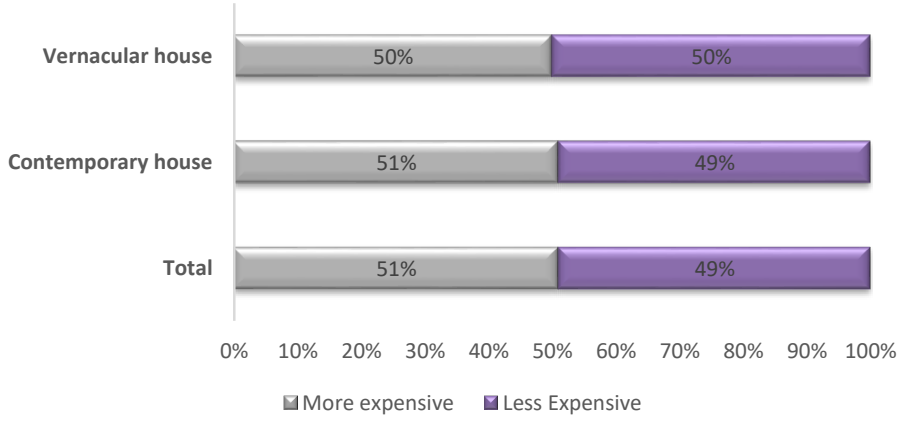
Table 5.23 and Figure 5.24 show that more than 48% (47/98) of the whole respondents had no knowledge concerning low energy houses, while 52% (51/98) had knowledge about it. Table 6.30 shows that 57% (49/86) of the respondents in contemporary area are strongly knowledgeable on the topic of highly energy efficient homes. (Table 5.24), but less than half (43%,37/86) response indicate a lack of information. Respondents who visit or consume visual media and or take part in social gatherings tend to be more knowledgeable and informed on highly energy efficient homes and some possess specialisation in the fields of sustainability and energy design.

The results in Table 5.23 indicate that 83% (10/12)) of the respondents in vernacular house have no knowledge on low energy houses. This means that people are unaware of the

impact which sustainable houses design could have on their own lives if it was provided. From this, it can be assumed that more information on low energy design through different kinds of media could be beneficial.

Table 5.24: *knowledge concerning low energy house*

	More expensive	Less expensive	Total	%
Vernacular house	1	1	2/12	
Percentage	50%	50%		
Contemporary house	25	24	49/86	
Percentage	51%	49%		
Total	26	25	51/98	
Percentage	51%	49%	100%	



Answer	Reasons
More expensive (51%)	• It needs special materials • The building materials used are very expensive; • It depends on using new technologies; • It is very expensive because the building materials are imported.
Less expensive (49%)	• The results of using these kind of building concepts can be seen after a period of time; • It is dependent on using natural resources;

Figure 5.25: *Cost of sustainable, low energy house*

The second subsection indicated that 51% (26/51) of those who answered yes (in Q19/A) assumed that low energy houses are more expensive than their current houses and the other 49% (25/51) thought that they were cheaper. They gave the reasons presented in (Table 5.24 and Figure 5.25). The respondent's thoughts on why a sustainable house would be more or less expensive than a contemporary house were recorded in Figure 5.26.

- **adoption of sustainable, low energy house**

The respondents who answered yes in question 20 (51/98) of vernacular house and contemporary house were asked the following question:

Q20	Do you agree or disagree that Iraqi buildings need to adopt more energy efficient designs that would save energy and reduce CO2 emissions.	Please tick the appropriate box	
			Yes
			No

This question was designed to investigate the respondents' agreement to promote sustainable, low energy design. A decisive indication is that 96% (49/51) of participants answering yes in question 20, agree to promote sustainable, low energy houses in Iraq in the future (Table 5.25 and Figure 5.26).

Table 5.25`: *Adoption low energy house in future*

	Yes	No	Total
Vernacular house	1	1	2/12
Percentage	2%	2%	
Contemporary house	48	1	49/86
Percentage	94%	2%	
Total	49	2	51/98
Percentage	96%	4%	100%

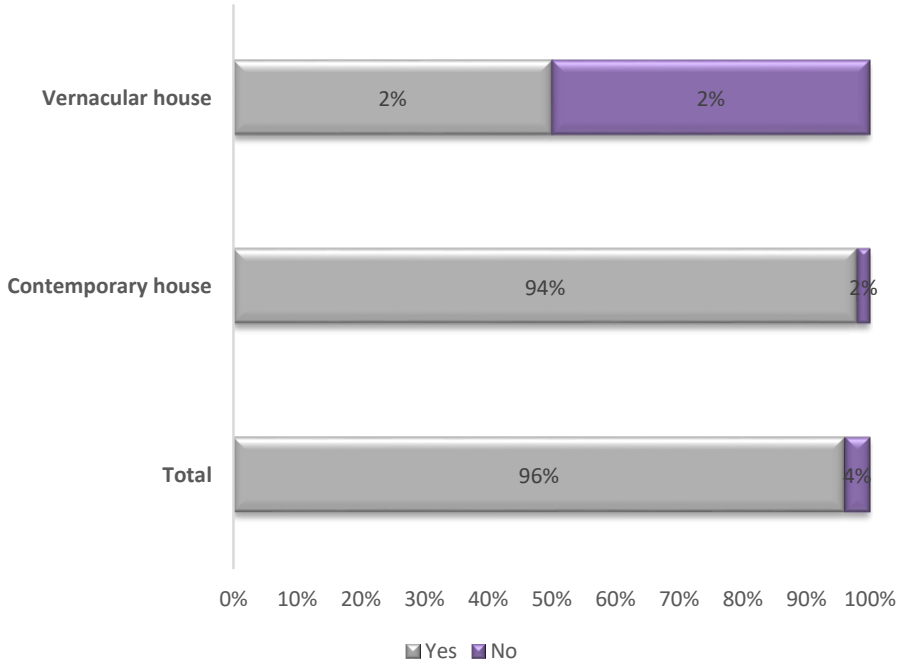


Figure 5.26: *Adoption low energy house in future*

- **Beneficial of sustainable, low energy house**

The respondents who answered yes in question 20 (51/98) of vernacular house and contemporary house were asked the following question:

Q20	What do you think about reducing carbon footprint when it comes to domestic buildings?	Please tick the appropriate box	
			good for me/my family
			good for the nation middle east
			good for the world
			Neutral
			No benefit

Table 5.26: *Rational behind the beneficial of sustainable house*

	Good for me/my family	Good for the nation middle east	good for the world	Neutral	Total
Vernacular house	1	1	0	0	2/12
Percentage	50%	50%	0%	0%	
Contemporary house	8	15	23	3	49/86
Percentage	16%	29%	45%	6%	
Total	9	16	23	3	51/98
Percentage	18%	31%	45%	6%	100%

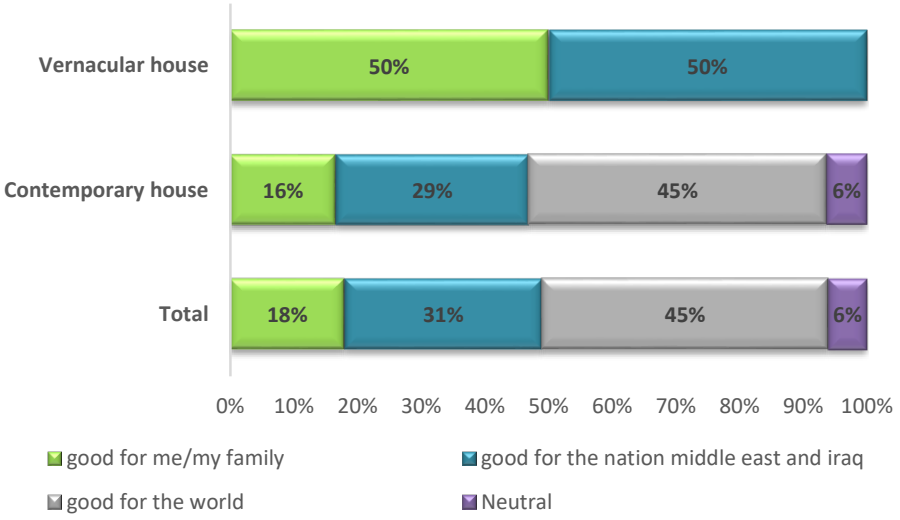


Figure 5.27: *Rational behind the benefit of sustainable house*

Table 5.26 and Figure 5.27 show that 94% of respondents, who answered yes in question 20, agreed that sustainable, low energy houses could benefit their family, the Middle East or even the world. Table 5.26 and Figure 5.27 summarises this result. The results show that 52% of all respondents are aware of the benefit of sustainable houses.

5.2.6 Part F: Public acceptance in terms of sustainable as well as energy retrofitting, low energy houses

This section presents the analysis of the respondents (98) to find out their opinion on which levels people tend to accept the design elements of retrofitting homes for more sustainability and energy efficiency.

- **Respondents' opinions on the future house**

All respondents (98) of vernacular house and contemporary house were asked the following question:

		Please tick one box	
Q22	What are your wishes that new houses must achieve?		Comfort
			Beauty
			Economic
			Safety
			All of the prior reasons

Table 5.27: *Needs for the future house*

Respondents	Future houses					Total	%
	Comfort	**Beauty**	**Economic**	**Safety**	**All of the prior reasons**		
Vernacular house	3	0	0	3	6	12	12%
Percentage	25%	0%	0%	25%	50%	100%	
Contemporary house	14	11	7	11	43	86	88%
Percentage	16%	13%	8%	13%	50%	100%	
Total	17	11	7	14	49	98	
Percentage	18%	11%	7%	14%	50%	100%	

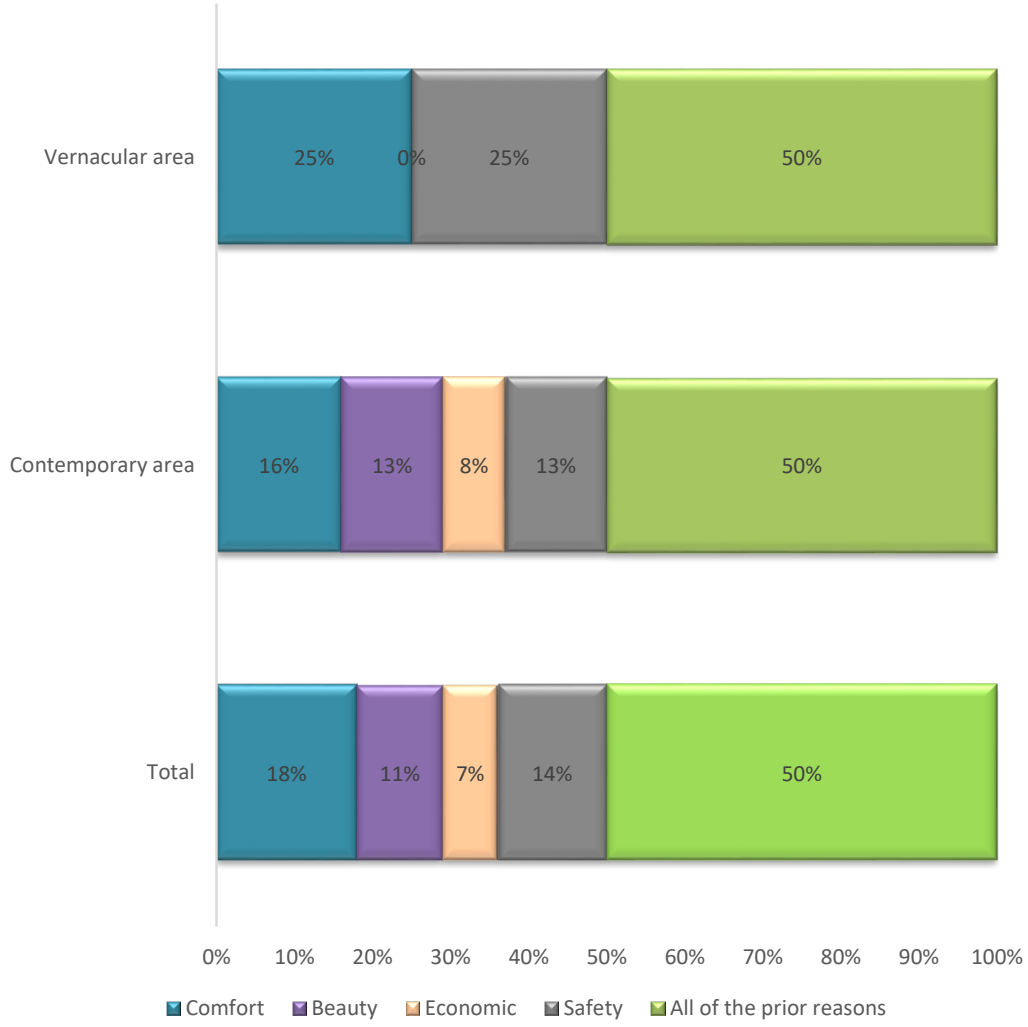


Figure 5.28: ***Needs for the future house***

This question asked to investigate what the respondents felt they needed in their houses in the future. Table 5.27 and Figure 5.28 show that the most popular choices (in the contemporary house) were for safety, beauty, and comfort, which accounted for 42% (36/86). Whereas, the priority choices in the vernacular house were be associated with safety and comfort which accounted for 50% (6/12). This shows that residents in both houses are looking for the same needs in houses in the future and thus the suggested guidelines will be useful for all residents in Baghdad.

The results shown in (Table 5.27 and Figure 5.28) show that 50% (49/98) of respondents in both houses chose all the reasons cited in the table.

- **Respondents' opinions on the potential of certain actions to save energy in future homes**

All respondents (98) of vernacular house and contemporary house were asked the following question:

	How would agree or disagree with methods of installation that would contribute to saving energy and increase sustainability?		Strongly agree	Agree	Neutral	Disagree	Strongly disagree
Q23	energy Reduce consumption	install solar electricity generation system, i.e. photovoltaic, (PV), in order to reduce consumption from the national electricity grid supply					
		use solar radiations for water heating to save energy					
		install shading devices around windows in order to save energy consumption					
		Replace single glazing with an efficient double or triple glazing minimizes heat losses\heat gain.					
		Install a grey water recycling system for irrigation purposes.					
	Shortage of information on products	Give the people awareness of low carbon energy buildings					
		There are shortages of sustainable products such as PV on the Iraqi market					
		The government should regulate the market and establishments to promote sustainable buildings					

A fundamental aim and objective of the survey was to assess people's willingness to adopt low energy design measures. Accordingly, in this question, respondents were asked about the potential of certain actions to save energy (Table 5.28, Figure 5.29 and 5.30).

Table 5.28: *Respondents perceptions of actions to save energy in future homes*

Install solar electricity generation system, i.e. photovoltaic, (PV), in order to reduce consumption from the national electricity grid supply							
	Strongly disagree	**Disagree**	**Neutral**	**Agree**	**Strongly agree**	**Total**	
Contemporary house	2	5	14	23	42	86	88%
Percentage	2%	5%	14%	24%	43%		12%
Vernacular house	0	0	2	8	2	12	
Percentage	0%	0%	2%	8%	2%		
Total	2	5	16	31	44	98	
Percentage	2%	5%	16%	32%	45%	100%	
Use solar radiations for water heating to save energy							
	Strongly disagree	**Disagree**	**Neutral**	**Agree**	**Strongly agree**	**Total**	
Contemporary house	2	4	14	27	39	86	88%
Percentage	2%	4%	14%	28%	40%		
Vernacular house	0	0	1	9	2	12	12%
Percentage	0%	0%	1%	9%	2%		
Total	2	4	15	36	41	98	
Percentage	2%	4%	15%	37%	42%	100%	
Install shading devices around windows in order to save energy consumption							
	Strongly disagree	**Disagree**	**Neutral**	**Agree**	**Strongly agree**	**Total**	
Contemporary house	1	2	7	31	45	86	88%
Percentage	1%	2%	7%	32%	46%		
Vernacular house	0	0	2	6	4	12	12%
Percentage	0%	0%	2%	6%	4%		
Total	1	2	9	37	49	98	
Percentage	1%	2%	9%	38%	50%	100%	
Replace single glazing with an efficient double or triple glazing minimizes heat losses\heat gain.							
	Strongly disagree	**Disagree**	**Neutral**	**Agree**	**Strongly agree**	**Total**	
Contemporary house	5	6	9	20	46	86	88%
Percentage	5%	6%	9%	21%	47%		
Vernacular house	0	1	2	7	2	12	12%
Percentage	0%	1%	2%	7%	2%		
Total	5	7	11	27	48	98	
Percentage	5%	7%	11%	28%	49%	100%	

Install a grey water recycling system for irrigation purposes							
	Strongly disagree	Disagree	Neutral	Agree	Strongly agree	Total	
Contemporary house	2	5	14	23	42	86	88%
Percentage	2%	5%	14%	24%	43%		
Vernacular house	0	0	2	8	2	12	12%
Percentage	0%	0%	2%	8%	2%		
Total	3	4	17	30	44	98	
Percentage	3%	4%	17%	31%	45%	100%	
Give the people awareness of low carbon energy buildings							
	Strongly disagree	Disagree	Neutral	Agree	Strongly agree	Total	
Contemporary house	1	1	8	21	54	86	88%
Percentage	1%	1%	8%	22%	55%		
Vernacular house	0	0	3	8	2	12	12%
Percentage	0%	0%	3%	8%	2%		
Total	1	1	11	29	56	98	
Percentage	1%	1%	11%	30%	57%	100%	
There are shortages of sustainability products, for instance the PV systems on the Iraqi markets							
	Strongly disagree	Disagree	Neutral	Agree	Strongly agree	Total	
Contemporary house	3	6	12	22	43	86	88%
Percentage	3%	6%	12%	23%	44%		
Vernacular house	0	0	3	6	3	12	12%
Percentage	0%	0%	3%	6%	3%		
Total	3	6	15	28	46	98	
Percentage	3%	6%	15%	29%	47%	100%	
The government should regulate the market and establishments to promote sustainable buildings							
	Strongly disagree	Disagree	Neutral	Agree	Strongly agree	Total	
Contemporary house	0	1	4	12	69	86	88%
Percentage	0%	1%	4%	13%	70%		
Vernacular house	0	0	2	2	8	12	12%
Percentage	0%	0%	2%	2%	8%		
Total	0	1	6	14	77	98	
Percentage	0%	1%	6%	15%	78%	100%	

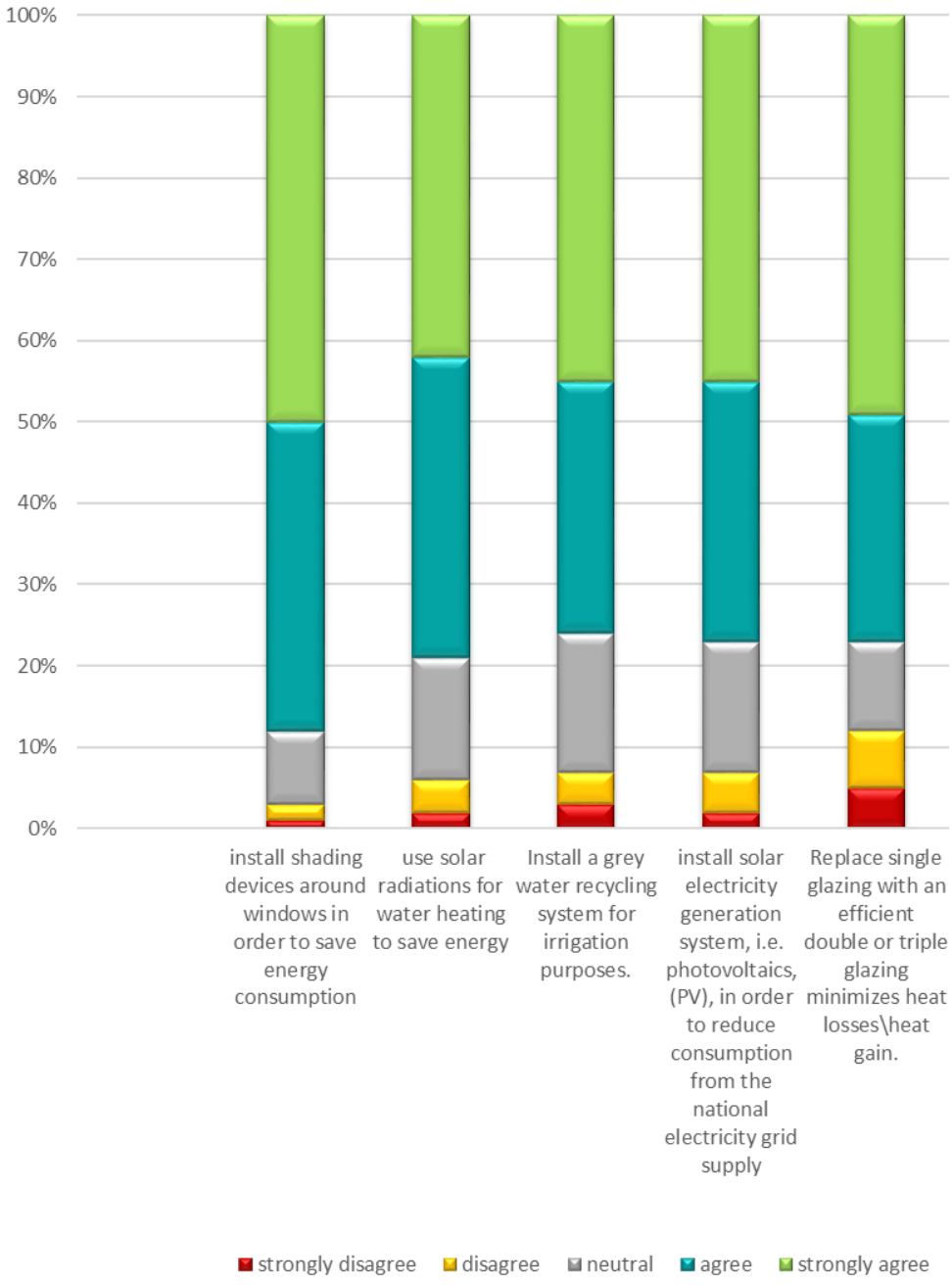


Figure 5.29: *Respondents' perceptions of actions to save energy in future homes*

As showed in Table 5.28 and Figure 5.29, over 32% (31/98) of participants agreed and 45%(44/98) strongly agreed that homeowners should add PV systems for generating energy. Additionally, Figure 5.30 demonstrates different approaches and attitudes to advocate energy efficient and sustainable homes. Participants agreed that energy

consumption can be reduced by using solar (renewable) energy for the purpose of hot water tanks instead of using electrical energy generated from fossil fuels and can reduce energy demands. Respondents also agreed that by implementing shades around windows or sources of light, houses may tend to remain cooler more naturally and automatically reducing energy demands for cooling especially when compared to single glazed windows as shown in Figure 5.29.

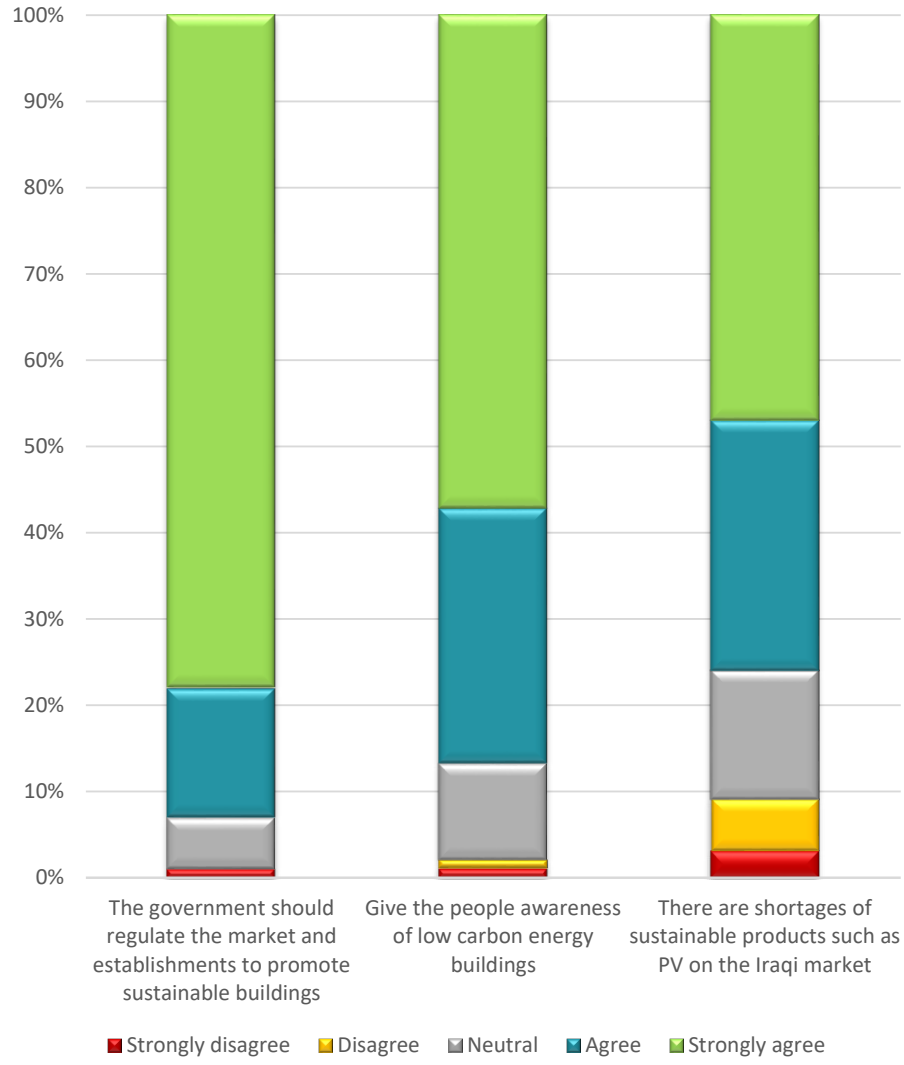


Figure 5.30: *Government action to save energy in future homes*

As a final point, over 87% (85/98) of respondents strongly agreed (57%, 56/98) or agreed (30%, 29/98) that the lack of householders' awareness around sustainable or low energy buildings, would result in a substantial increase of energy demand (Table 5.29 and Figure 5.31). However, it is worth noting that there is a shortage of sustainable products, such as

PV, in the Iraqi market, as illustrated in Figure 5.31. Over 93% (91/98) of respondents strongly agreed or agreed that the government should regulate the market and promote the wide availability of necessary low carbon and renewable products (Figure 5.31).

- **Respondents' opinions on the future plans of residential buildings**

All respondents (98) of vernacular house and contemporary house were asked the following question:

Q24	In designing future dwellings how important are each of the following factors to reduce energy (Please tick the appropriate box) Please answer the following questions about future dwelling in Baghdad					
		1.strongly agree	**2. agree**	**3. neutral**	**4. disagree**	**5. Strongly disagree**
	Future dwellings in Iraq\Baghdad must be designed to save energy consumption					
	The future dwellings in Iraq\Baghdad must be designed according to sustainable, low energy criteria established as compulsory by the government					
	The government should take serious action and steps to introduce rules to adopt low energy building in Iraq					

This question was asked in order to investigate what the respondents' views were on the design of future homes.

Table 5.29 and Figure 5.31 show the public perception in terms of using low energy and sustainable houses in Baghdad in the future.

Table 5.29: *Public perception in terms of using low energy and sustainable houses in Baghdad in the future.*

Future dwellings in Iraq\Baghdad must be designed to save energy consumption							
	Strongly disagree	**disagree**	**Neutral**	**Agree**	**Strongly agree**	**Total**	
Contemporary house	1	1	1	14	69	86	88%
Percentage	1%	1%	1%	14%	70%	12	12%
Vernacular house	0	0	1	8	3		
Percentage	0%	0%	1%	8%	3%		
Total	1	1	2	22	72	98	
Percentage	1%	1%	2%	23%	73%	100%	
The future dwellings in Iraq\Baghdad must be designed according to sustainable, low energy criteria established as compulsory by the government							
	Strongly disagree	**disagree**	**Neutral**	**Agree**	**Strongly agree**	**Total**	
Contemporary house	0	6	8	26	46	86	88%
Percentage	0%	6%	8%	27%	47%		
Vernacular house	0	0	10	1	1	12	12%
Percentage	0%	0%	10%	1%	1%		
Total	0	6	18	27	47	98	
Percentage	0%	6%	18%	28%	48%	100%	
The government should take serious action and steps to introduce rules to adopt low energy building in Iraq							
	Strongly disagree	**disagree**	**Neutral**	**Agree**	**Strongly agree**	**Total**	
Contemporary house	0	0	7	25	54	86	88%
Percentage	0%	0%	7%	26%	55%		
Vernacular house	0	0	2	2	8	12	12%
Percentage	0%	0%	2%	2%	8%		
Total	0	0	9	27	62	98	
Percentage	0%	0%	9%	28%	63%	100%	

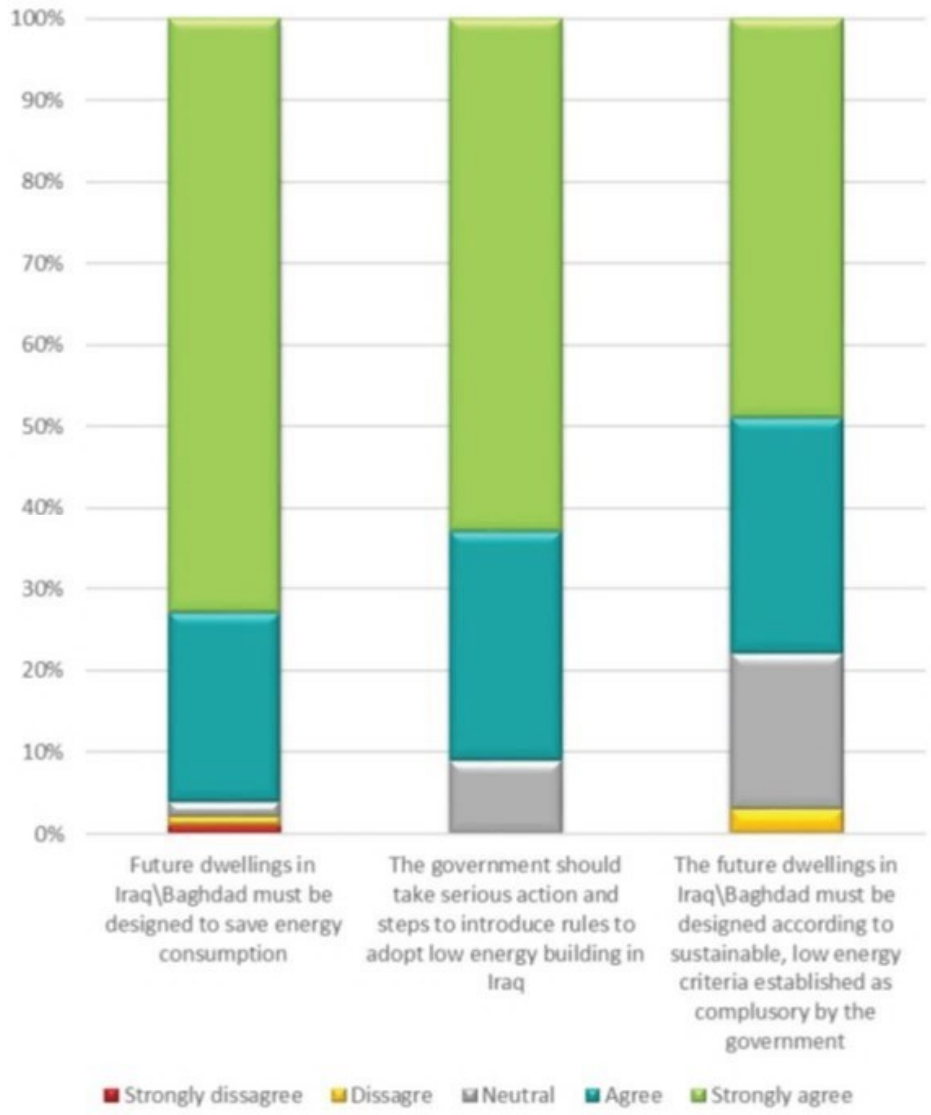


Figure 5.31 *Public perception in terms of using low energy and sustainable houses in Baghdad in the future.*

The positive side of planning for the future of residential buildings is that, as shown in Table 5.29 and Figure 5.31, the majority (96%,94/98) of respondents strongly agreed (73%,72/98), or agreed (23%,22/98), that future dwellings in Baghdad must be designed to take into account the need to save energy and reduce CO2 emissions.

This percentage highlights the overwhelming willingness of the public to accept sustainable buildings, although probably some aspects will experience slow acceptance/adoption, especially those related to the size of the houses or reduction in the number of rooms. It is worth noting that around 20%(17/98) of respondents strongly agreed or agreed on reducing houses' overall area (Figure 6.39), but this percentage is

relatively so low compared with the acceptance of other suggestions, such as the installation of PV. On the other hand, around 91% (89/98) of respondents strongly agreed or agreed that the governmental sector, such as the Ministry of electricity, the Ministry of housing and the Ministry of municipalities, should take serious steps to regulate the building sector in Baghdad in term of saving energy and conservation.

5.2.7 Part G: Social barriers in the use of low energy homes

All respondents (98) of vernacular house and contemporary house were asked the following question:

	Please indicate your point of view on the following socio-cultural issues					
		1.Strongly agree	2. Agree	3. Neutral	4. Disagree	5.Strongly disagree
Q25	Would you regard the size of someone's house as a symbol of the person's status in society?					
	Would you agree to live in a smaller house in order to reduce energy demands?					
	Would you agree to socialize with your neighbors?					
	Would you agree to have only one guest room for both genders?					
	Would you agree to have bedroom appropriate sized to fit the needs of occupant?					
	Would you agree for using garden in house for social gathering?					
	Would you agree for using roof for sleeping purpose?					

There exist a few barriers that can be identified as 'cultural' barriers that slow down or reject the promotion of energy efficient and sustainable methods in Baghdad. (Table 5.30 and Figure 5.32). There are a range of sub-factor considerations under the social and cultural category, while privacy from the public realm can be seen as the overarching factor to be adopted in informing contextually appropriate home design (Figure 5.32).

Table 5.30: *Views of the public on social barriers that hinder the adoption of low energy and sustainable houses in Baghdad.*

Would you regard the size of someone's house as a symbol of the person's status in society?							
	strongly disagree	**disagree**	**neutral**	**agree**	**strongly agree**	**Total**	
Contemporary house	1	2	7	31	45	86	88%
Percentage	1%	2%	7%	32%	46%		
Vernacular house	0	0	2	6	4	12	12%
Percentage	0%	0%	2%	6%	4%		
Total	4	24	27	20	23	98	
Percentage	4%	24%	27%	21%	24%	100%	
Would you agree to live in a smaller house in order to reduce energy demands?							
	strongly disagree	**disagree**	**neutral**	**agree**	**strongly agree**	**Total**	
Contemporary house	23	27	20	13	3	86	88%
Percentage	24%	28%	20%	13%	3%		
Vernacular house Percentage	66%	55%	00%	11%	00%	12	12%
Total	29	32	20	14	3	98	
Percentage	30%	33%	20%	14%	3%	100%	
Would you agree to socialize with your neighbours?							
	strongly disagree	**disagree**	**neutral**	**agree**	**strongly agree**	**Total**	
Contemporary house	10	20	18	23	11	86	88%
Percentage	10%	21%	19%	24%	11%		
Vernacular house	0	0	2	7	3	12	12%
Percentage	0%	0%	2%	7%	3%		
Total	10	20	20	34	14	98	
Percentage	10%	21%	21%	35%	14%		100%
Would you agree to have only one guest room for both genders?							
	strongly disagree	**disagree**	**neutral**	**agree**	**strongly agree**	**Total**	
Contemporary house	1	1	4	34	46	86	88%
Percentage	1%	1%	4%	35%	47%		
Vernacular house	0	3	7	1	1	12	12%
Percentage	0%	3%	7%	1%	1%		
Total	1	4	11	35	47	98	
Percentage	1%	4%	11%	36%	48%	100%	

Would you agree to have bedroom appropriate sized to fit the needs of occupant?							
	Strongly disagree	Disagree	Neutral	Agree	Strongly agree	Total	
Contemporary house	2	7	23	32	22	86	88%
Percentage	2%	7%	23%	33%	23%		
Vernacular house	0	0	1	6	5	12	12%
Percentage	0%	0%	1%	6%	5%		
Total	2	7	24	38	27	98	
Percentage	2%	7%	24%	39%	28%	100%	
Would you agree for using garden in house for social gathering?							
	Strongly disagree	Disagree	Neutral	Agree	Strongly agree	Total	
Contemporary house	0	1	4	12	69	86	88%
Percentage	0%	1%	4%	13%	70%	12	12%
Vernacular house	0	0	2	2	8		
Percentage	0%	0%	2%	2%	8%		
Total	3	22	26	31	17	98	
Percentage	3%	22%	27%	32%	17%	100%	
Would you agree for using roof for sleeping purpose?							
	Strongly disagree	Disagree	Neutral	Agree	Strongly agree	Total	
Contemporary house	0	1	4	12	69	86	88%
Percentage	0%	1%	4%	13%	70%	12	12%
Vernacular house	0	0	2	2	8		
Percentage	0%	0%	2%	2%	8%		
Total	2	26	26	34	10	98	
Percentage	2%	27%	26%	35%	10%	100%	

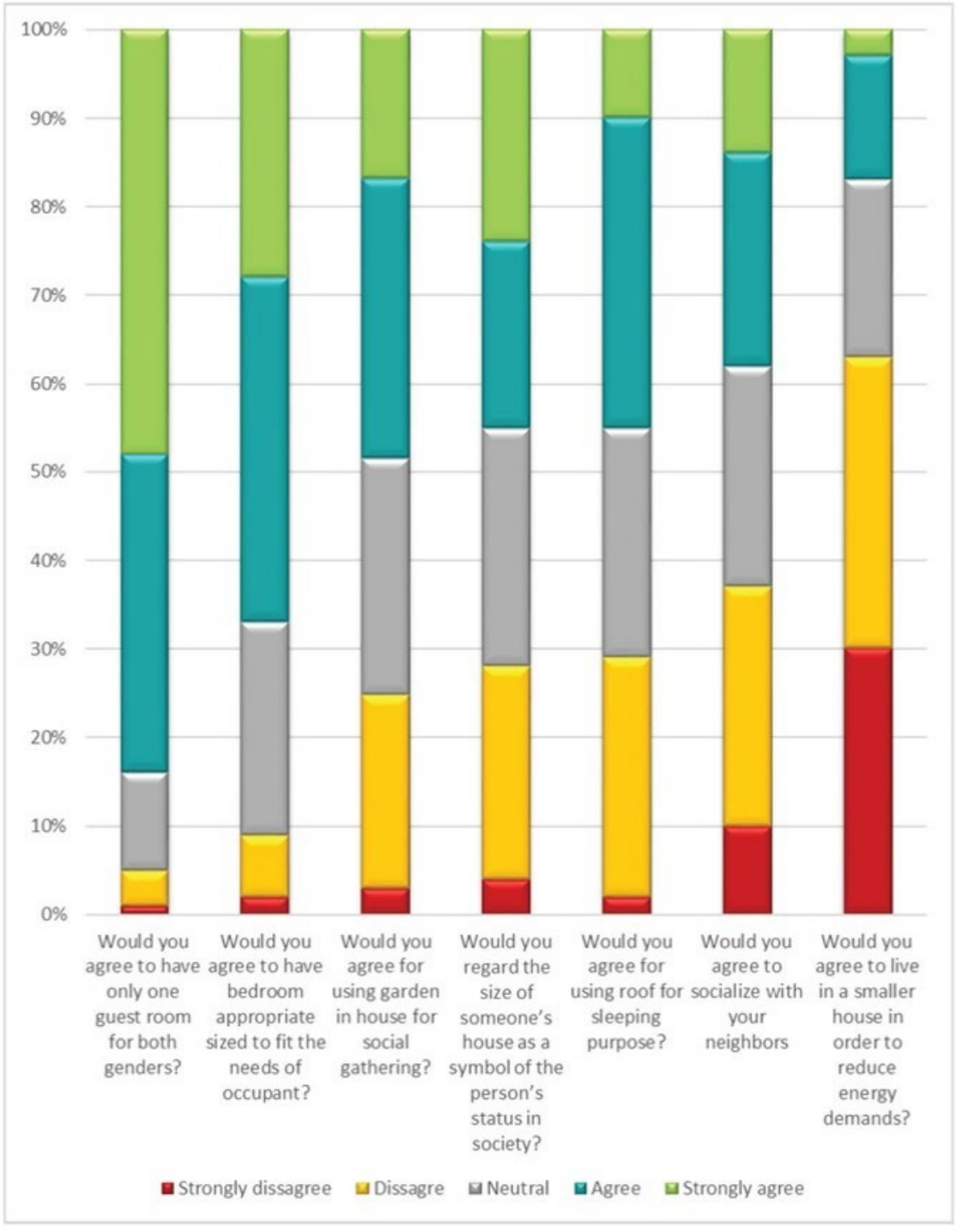


Figure 5.32: *Views of the public on social barricades that hinder the adoption of low energy and sustainable houses in Baghdad.*

Table 5.30 and Figure 5.32 show that 45% (43/98) of respondents strongly agreed (24%, 23/98) or agreed (21%, 20/98) that the building size and area are symbols of a person's

status or position in society. Over 63% (61/98) of respondents strongly disagreed or disagreed about reduction in building size to consume less energy.

It has been found from literature and questionnaire responses are that the courtyard of the vernacular house provides occupants with complete privacy when they use it for their daily activities and social gatherings. However, the garden in contemporary houses does not provide occupants with complete privacy when they use it for social gatherings. A positive point to meet the social-cultural requirements is that the majority of respondents strongly agreed or agreed to socialise within their neighbourhoods and can use gardens for social gatherings with some modification (Table 5.31 and Figure 5.33). The future house can have a garden as well with a courtyard as the aim of the future design is to satisfy the socio-cultural needs of its inhabitants. When designing the external walls of the future house, it should be high enough to prevent overlooking by neighbours and passers-by. So the courtyard aspects of the vernacular house designed to meet the socio-culture barriers desired by contemporary day culture in Baghdad would be appropriate in the future house and it is suggested it will be applied to the design strategies.

It has been found from literature and questionnaire responses are that the courtyard of the vernacular house provides occupants with complete privacy when they use it for their daily activities and social gatherings. However, the garden in contemporary houses does not provide occupants with complete privacy when they use it for social gatherings. A positive point to meet the social-cultural requirements is that almost the half of respondents (49 %, 48/98) strongly agreed or agreed to socialise within their neighbourhoods and can use gardens for social gatherings with some modification (Table 5.30 and Figure 5.32). The future house can have a garden as well with a courtyard as the aim of the future design is to satisfy the socio-cultural needs of its inhabitants.

As seen in Table 5.30 and Figure 5.32, 84% (83/98) of respondents strongly agreed (48%, 47/98) or agreed (36%, 35/98) that there is no need for guest rooms and spaces, which have been designed particularly for male inhabitant's visitors. Some of these barriers are rooted in tradition and religion (e.g. no mixed genders in a room). There are two different options between some older participants and younger participants of the vernacular house regarding the guest rooms. The older participants (25%, 3/12) believed that such a guest room, which have been designed particularly for male inhabitant's visitors, is needed but the younger participants believed that there is no need for guest rooms and

spaces, which have been designed particularly for male inhabitant's visitors and they wish to have one guest room. However, the majority of the participants of the contemporary house (82%, 80/86), both older and younger participants, are happy with mixed genders in a room and they strongly agree or agree that no need for guest rooms and spaces, which have been designed particularly for male inhabitant's visitors. This means many families do not need additional rooms specially to receive adult male visitors, thereby reducing the area requiring cooling, heating and lighting.

A positive point to meet the social-cultural requirements is that the characteristics of the roof terrace could be applied to the future design strategies. 45% (44/98) of respondents agreed or strongly agreed that the roof terrace could be used as a sleeping area overnight during the summer (Table 5.30 and Figure 5.32). On the other hand, 27% (26/98) of respondents disagreed with using the roof as sleeping area during the summer and explained this was because the wall was not high enough to prevent overlooking. Such a roof terrace could satisfy the inhabitant's needs and provide them with complete privacy if the parapet wall was high enough to prevent overlooking by neighbours.

At the end of questionnaires, respondents were invited to suggest problems affecting their homes which were not covered in the questionnaire, the questionnaire reached 98 participants, 15 of whom (15%) were completed the final questionnaire successfully. These responses focused on developing the microclimate condition in the city and are summarised in the following points:

- Providing good landscape design and using trees can make a pleasant environment;
- Providing shaded areas can reduce heat gain;
- Using bright colours in facades helps to reflect the sun.

5.3 Key findings from the public survey

As stated previously, the questionnaire was distributed in Iraq, Baghdad. The following discussion presents the main findings from both contemporary and vernacular houses.

Part A: General information

- The main age group of respondents was 25-34 years and belonged to both genders.
- 49% (48/98) of respondents were females, which is enough to provide a reasonable reflection of their opinions.
- Majority of the respondents from the contemporary house held postgraduate degrees and a high percentage of them were employed. Whereas most of the respondents in vernacular house held Diploma certificates.
- 62% (61/98) of families in both house types, lived in houses with 5-8 occupants, that can correspond to a huge amount but it is expected as Iraqis have larger families.
- The demographic information collected from the respondents, clearly indicates that all the respondents were able to provide reliable opinions on the conditions of living in vernacular and contemporary housing. They had sufficient experience of the house types, were able to understand the questions and respond.

An assessment of the respondents' opinions about the dwelling conditions in both houses can be summarized as follows:

Part B: Local domestic stock typology and current problems

- High percentages (55%, 54/98) of respondents were owners of houses they were residing in.
- 100% (98/98) of respondents live in a house and 89% (87\98) of the respondents have lived in their dwellings for more than 5 years.
- Half of the respondents (49/98) live in dwellings with an area of 200 m^2.
- 49% (42/86) of respondents in contemporary houses were satisfied with its ability to meet their needs in summer and the other 48% (41/86) were not, whereas 91% (11/12) were satisfied with vernacular houses and the rest (8%,1/12) were neither satisfied nor dissatisfied.

- Based on the results from previous point it can be confirmed that respondents were aware of the vernacular house importance in providing satisfaction and pleasant indoor thermal comfort.

Part C: Energy consumption patterns, levels of satisfaction of energy usage and thermal comfort

- 82% (81/98) of respondents occupied their homes for long periods (6 hours or more) per day
- 67% (58/86) of the respondents from the contemporary house used air-conditioning; 9% (5/58) of those respondents used it all year, while 55% (32/98) used it during the summer time and 31% when the temperature was very high. On the other hand, 8% of the respondents from the vernacular house use air-conditioning but only in the living room or in the guest room when the temperature is very high. These results indicate that air-conditioning had become an important element in achieving internal thermal comfort for contemporary houses.
- 79% (47/59) of respondents used air-conditioning for 10-24 hours a day. This provided an insight on the amounts of KWh being utilised for operating air-conditioning in hot summers.
- 80% (69/86) of the respondents from the contemporary area and 75% (9/12) of the respondents from the vernacular house stated that they feel uncomfortable when the temperature goes above 30°C.
- 76% (66/86) of the respondents from the contemporary house and 83% (10/12) of the respondents from the vernacular house chose to open windows to get cross air currents as a solution to escape high temperatures when air-conditioning is not available. This indicates the importance of the windows' location and size in achieving suitable air movements.

Part D: Public perception and knowledge about vernacular design via contemporary design

- 89 % (87/98) of all respondents wanted courtyards in either current or upcoming homes.

- The results of the most common motive for using vernacular features, such as a courtyard, show a mix of cultural as well as environmental qualities which were recognised by respondents:
- 25% (24/98) of the respondents indicated that strong family ties as well as social spaces are the highly desirable qualities of courtyards. In terms of other potential qualities, about 21% (20/98) identified green spaces, 14% (14/98) recognised privacy, 9% (9/98) identified spaciousness and openness, 6% (6/98) identified relaxation, calmness and tranquillity, 5% (5/98) identified natural sunlight, 7% (7/98) identified security and protection, 6% (6/98) identified cooling and natural ventilation, 4% (4/98) identified other qualities and 3% (3/98) identified identity and self-expression.
- Increased real estate costs were seen to be the most important cause in preventing the implementation of courtyards with 92% (90/98) of respondents strongly agreeing (75%, 74/98) or agreeing (17%,16/98), followed close by lands of small areas with 88% of respondents strongly agreed (66%,65/98) or agreed (23%, 22/98), Iraq's housing crisis with 85% of respondents who strongly agreed (53%, 52/98) or agreed (32%,31,98), scarcity of residential land with 76% (74/98) of respondents who strongly agreed (58%, 57/98) or agreed (18%, 17/98), and the absence of governmental regulations in promoting courtyards with 59% (58/98) of respondents who strongly agreed (27%, 27/98) or agreed (32%, 31/98).
- Therefore, Iraq's housing crisis could be held responsible for the abovementioned choices.
- 84% (83/98) of all the respondents preferred to live in houses that consisted of a combined house style (that is, a style containing both traditional and modern features and including modern technology).

Part E: Communal perceptions and awareness on low energy houses

- 52% (51/98) of all the respondents have knowledge on sustainable, low energy houses. However, 43% (37/86) of the respondents from the contemporary houses and 75% (9/12) of the respondents from the vernacular houses have no knowledge on sustainable, low energy houses. This means that more attention should be paid to inform people about the importance of applying sustainable concepts in their houses.

- 51% (26/51) of respondents who had knowledge of low energy houses thought they were more expensive than their current house and other 49% (25/51) thought that they were cheaper.
- 94% (48/51) of respondents who had knowledge on sustainable, low energy houses agreed that sustainable, low energy houses could benefit their family, the Middle East or even the world.

Part F: Public's acceptance of energy retrofitting along with sustainable, low energy houses

- 50% (49/98) of all the participants from both housing types chose comfort, beauty, cost, and safety as the main factors that should be taken in consideration when choosing future houses.
- Over 32% (31/98) of all the participants agree and 45% (44/98) of participants strongly agree that householder must connect PV systems for generating electricity in their homes.
- Over 88% (86/98) of participants agreed that external shading products can help in reducing the cooling demands as would replacement of single-glazed windows with effective double or triple covering.
- Over 87% (85/98) of participants agreed strongly (57%, 56/98) and 30% agreed (29/98) that lack of publi knowledge on energy efficient and sustainable buildings results in the increases in demands for energy.
- 93% (91/98) of all the participants agreed or strongly agreed that the government must work in regulating the markets and promoting the need for adopting products which are renewable as well as low carbon based.
- Majority of respondents (96%, 94/98) strongly agreed (73%, 72/98), or agreed (23%, 22/98), that upcoming houses in Baghdad should be designed for energy savings as well reducing carbon dioxide releases.
- 20% of respondents agreed for the reduction of overall areas of homes.
- Around 91% of respondents agree that government bodies such as Ministries of municipalities, housing and electricity must implement strict rules in regulating building sectors of Baghdad for saving and preservation of energy.

Part G: Social barricades to the delivery of low energy homes

- 45% (43/98) of respondents strongly agreed (24%, 23/98) or agreed (21%, 20/98) that the building sizes and covered areas are symbols of the statuses of people's public position.
- Over 63% (61/98) of respondents strongly disagreed or disagreed about reducing the size of the building to reduce energy consumption.
- 84% (83/98) of participants agree strongly (48%, 47/98) or agreed (36%, 35/98) with no need for guest rooms and areas specified for male inhabitants' visitors. Mainly, such barriers are a result of implementing traditional as well as religious teachings. This means many families do not need additional rooms specially for receiving gent guests, thereby reducing the area requiring cooling, heating and lighting.
- 45% (44/98) of the participants agreed or strongly agreed that the roof terrace could be used for sleeping overnight during the summer. However, 27% (26/98) of respondents disagreed with using the roof as an area for sleeping in the summer and explained this was because the wall was not tall enough for preventing peeking. Hence, if taller walls are used this can satisfy resident's needs.

The results show that the respondents are likely to accept the final guidelines where solutions will be suggested that include both vernacular architecture and passive solutions.

5.4 Conclusion

This chapter presents the perceptions of public in terms of homes with sustainability in Baghdad, Iraq. The work identifies those aspects which lead to increased consumptions in energy along with recognising the potential barriers in culture that result in the prevention of establishing houses which are sustainable. To do so, a survey was used to elicit the perceptions of public. These respondents possessed varying educational levels and belonged to varying age levels. Overall, the findings of this study highlighted the several aspects which lead to increased consumptions in energy in homes in Baghdad. Once such aspects were recognised, these were individually discussed in order to offer supervisory guidance on potential resolutions which can assist with the prevention of increased energy consumptions as well as the minimisation of CO_2 emissions relating to building design. Furthermore, the study has identified some cultural issues which cause hindrance in establishing houses with sustainability factors in Baghdad. Nevertheless, suggestions as well solutions have been portrayed in this chapter which can be implemented and their corresponding environmental, social and economic benefits are also discussed.

Public key findings		Issues	Need	Response
Satisfaction in relation to house type	• 91% (11/12) satisfied or very satisfied with vernacular houses. • 49% (42/86) satisfied with contemporary.	**Environmental conflicts**	**Satisfaction** Thermal comfort Cultural appropriateness	✓ looking at vernacular housing aspects which can be applied in new house
Thermal Comfort Factors	• 82% (81/98) of respondents occupied their homes for 6 hours or more per day	**Thermal comfort\ cooling strategies issues**	**Passive design strategies**	• Sun Shading; • Natural ventilation; • Thermal Mass; • Evaporative Cooling. Requirement to look at strategies to improve comfort throughout the day and the night when the temperature goes above 30°C.
	Requirement to look at strategies to improve thermal comfort throughout the day and the night • 93% require supplementary cooling, indicating that overheating is a major comfort issue. • 80% (78/98) of the respondents indicate that 30°C is "too high" • 20% (20/98) indicate that 25-30°C is "too high"			
	• 89%(87/98) wanted a courtyard, (44% for environment aspects, 21% for culture, 6% for esthetic and 2% unspecific).		**Natural ventilation system**	• Operable windows • Building shape • Space planning • Orientation • Strategies architecture features(courtyard) • Courtyard
	• 79% (47/59) of respondents used air-conditioning for 10-24 hours a day. This provided an insight on the amount of energy being used to operate the air conditioning during the hot summer period. However, it should be noted that electricity availability is intermittent, so Passive design strategies will have obvious benefits to solve this problem. • 78% (76/98) of the respondents indicate that ventilation is accepted as a response to cooling **when electricity is not available**. • 16%(16/98) indicate that sitting in the garden is accepted as a response to cooling when electricity is not available. However, 93% rate AC as providing good to excellent thermal comfort in comparison to 14% accepting natural ventilation as providing good to very good thermal comfort or 20% accepting shading devices as being efficient.		**Thermal mass**	• conventional construction material • Thermal Mass+ Insulation • Wall, roof and floor absorption coefficients and heat capacities
			Air Cconditioning (AC)	• Functional programme of use • Seasonal programme of use • Use sensor.
Design Factors	• Strong support for installing solar electricity generation, solar water heating, shading devices, and improved glazing (replacement of single glazed windows with effective double or triple glazing). • Strongly support for future house to save energy consumption, slightly less for government to establish compulsory criteria/rules. • Strongly support for future house to use a courtyard for environment aspects and socio-cultural aspects. • Strongly support the importance of the windows' location and size in achieving suitable air movements. • Strongly support for future house to consist of a combined house style (that is, a style containing both traditional and modern features and including modern technology). • 55% (32/98) of the respondents from the contemporary house used air-conditioning during the summer time and 31% when the temperature was very high. These results indicate that air-conditioning had become an important element in achieving internal thermal comfort for contemporary houses. • Agreement to only have one guest room for both genders and reduced bedroom sizes, using garden for socialising, sleep on roof	**Design issues**		• Requirement to look at strategies to improve design to save energy consumption tthroughout the day and the night. • Requirement to look at cooling design strategies to reduce energy cooling demand throughout the day and the night in summer time or in very high temperature.
			solar electricity generation	• Install PV systems
			Save energy	• Passive strategies ○ Massing and space layout ○ Window's Design ○ Building orientation ○ Building envelope ○ Using natural materials ○ Thermal mass
			Cooling design strategies	• building position with respect to wind • External shading device type and level • glazing type • building orientation • window orientation
			Shading	• Window shading
			Window design	• Window type • location and size • Glazing area \double or triple • window orientation
			Spaces	• One guest room • Reduce bedroom size • High the wall of roof • Garden with courtyard
			AC	• Functional programme of use • Seasonal programme of use • Use sensor
Socio-Cultural Factors	• Resistance to reducing housing size. • Strongly support for future house to use a courtyard for environment aspects and socio-cultural aspects. • Strong support for using garden for socializing • Strong support for using roof for sleeping overnight during the summer. A roof terrace could satisfy the inhabitant's needs and provide them with complete privacy if the parapet wall was high enough to prevent overlooking by neighbours.	**Socio-cultural**	• **Outside spaces** • **Privacy for outside sleeping spaces**	• Garden design with courtyard • High the wall of roof for privacy purposes.
Economic Factors	• High real-estate price • Available raw materials. • Low construction cost	**Economic**		

Chapter 6

Experts survey analysis and perception

6.1 Introduction

This chapter responds to objective 2 of this research, and it intends to capture the perceptions of relevant professionals on the feasibility of incorporating passive design strategies into a new low-energy design concept for Baghdadi dwellings. This feasibility was intended to consider not only the technical feasibility, but social and cultural aspects which may be a potential barrier to implementation.

It is important to take experts views on board in relation to the building of homes in the past and present. This is because it gives an understanding of the challenges the country faces in creating a modern Baghdad but it also gives the opportunity to look at how to design energy-efficient home considering Baghdad's climatic condition and culture.

This chapter presents a synthesis of the insights from professionals on the potential design of new residential homes in Baghdad elicited from a combination of face-to-face questionnaires and interviews (as described in the methodology listed in chapter three \Section 3.2.4). The data collected were analysed using Microsoft Excel software. Tables and figures were used for illustration and analytic purposes.

This chapter is structured into three main sections: results and results and analysis, key findings, and finally a concluding summary.

6.2 Results and Analysis

The researcher reached 61 participants, 48 of whom (78.6%) were interviewed and completed successfully the questionnaire in both phases and fully worked with the investigator along with offering innovative solutions as well as responses.

The survey was divided into 4 parts:

A. Demographic Information (presented in Section 6.2.1)
B. Opinions on design and construction relating to bioclimatic design of contemporary housing for Baghdad (presented in Section 6.2.2)
C. Opinions on efficient solutions to reduce energy demand of houses (presented in Section 6.2.3)

D. Perception of cultural barriers to the delivery of low energy houses (presented in Section 6.2.4)

Figure 6.1 shows the distribution of the panel of experts across the four chosen categories:

- Decision makers
- Academics
- Construction industry practitioners
- International

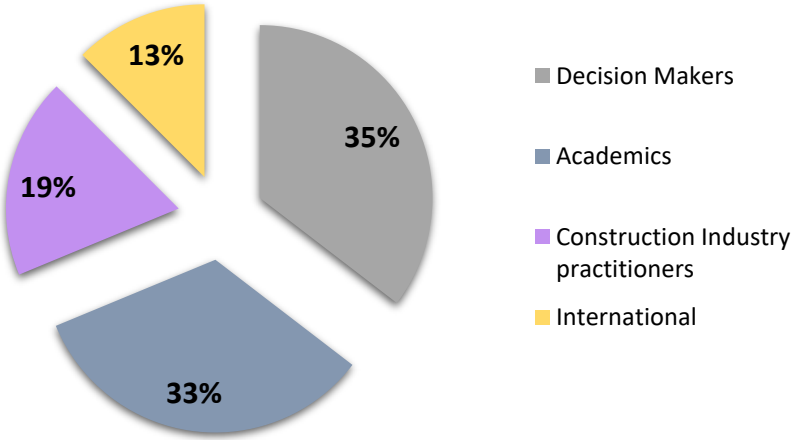


Figure 6.1: *Experts panel*

6.2.1 Part A: Demographic information

- **Gender and age of the respondents**

All respondents (48) were asked the following questions:

Q1:Gender?		Male
		Female
Q2: Age?		From 30-39
		From 40-49
		From 50-60
		More than 60

This question investigated the respondent's gender and age.

Table 6.1: *Expert Respondent's gender and age*

	Age	30-39	40-49	50-60	More than 60	Total
Decision Makers	Male	1	2	4	5	12/17
	%	8%	17%	33%	42%	100%
	Female	1	2	1	1	5/17
	%	20%	40%	20%	20%	100%
Academics	Male	2	4	3	1	9/16
	%	20%	40%	30%	10%	100%
	Female	1	3	2	1	7/16
	%	14%	43%	29%	14%	100%
Construction Industry practitioners	Male	2	2	1	3	8/9
	%	25%	25%	13%	37%	100%
	Female	0	1	0	0	1/9
	%	0%	100%	0%	0%	100%
International	Male	0	1	2	3	6/6
	%	0%	17%	33%	50%	100%
	Female	0	0	0	0	0/6
	%	0%	0%	0%	0%	100%
Total		7	15	13	14	48
Percentage		13%	31%	27%	29%	100%

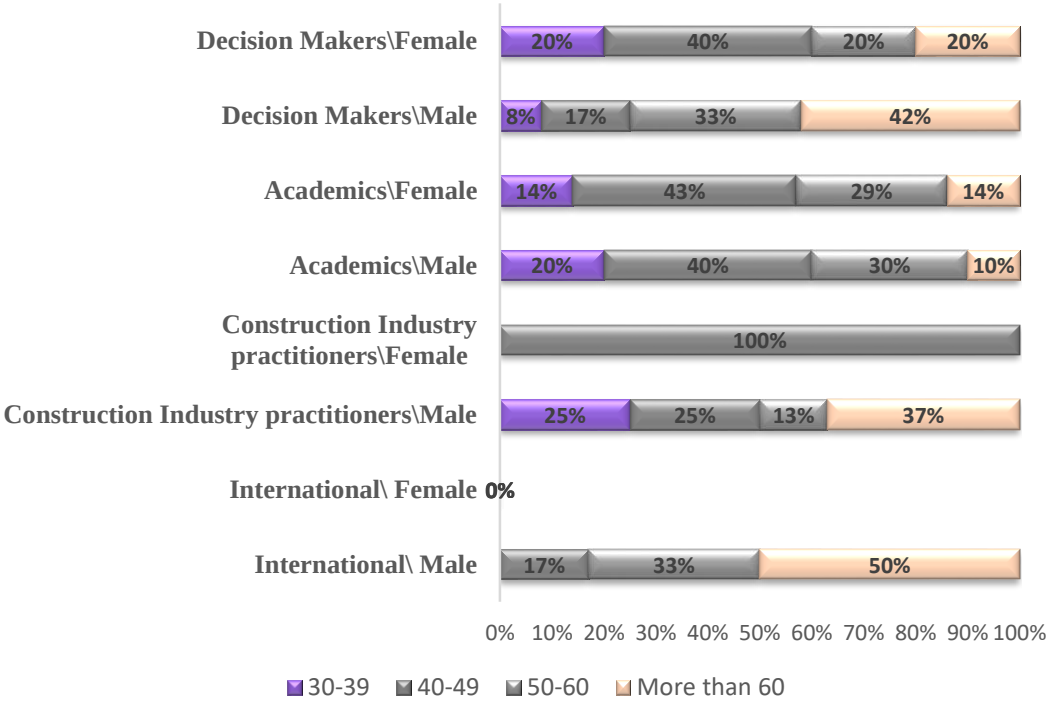


Figure 6.2: *Expert Respondents' age and gender*

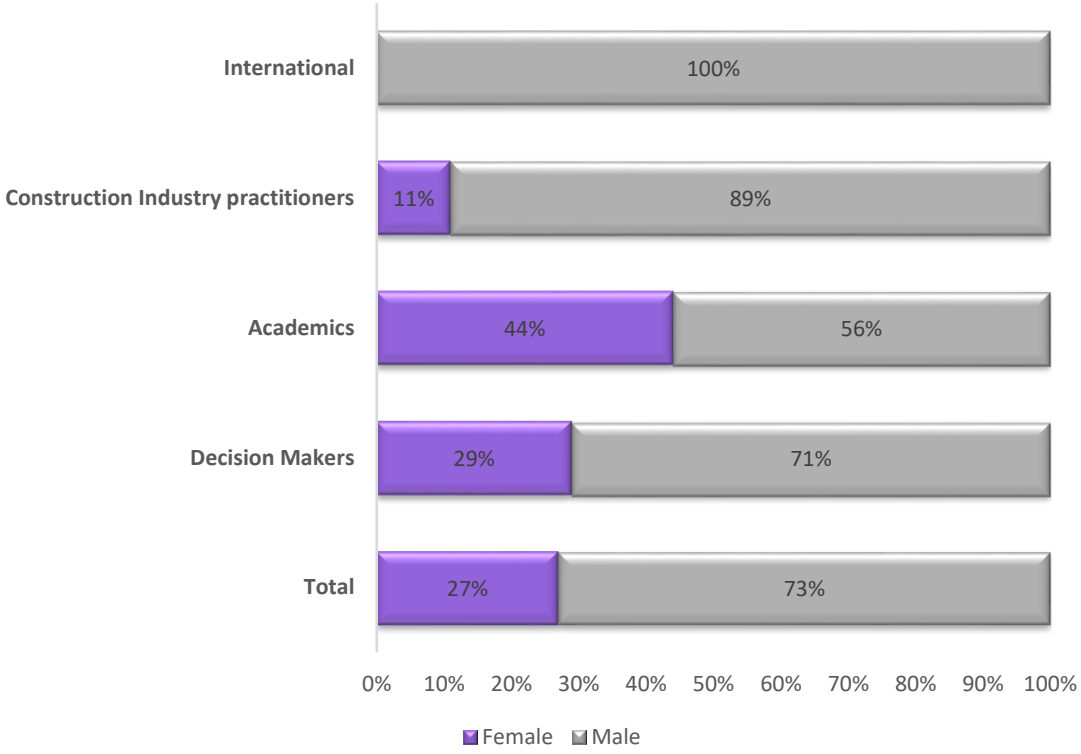


Figure 6.3: *Expert Respondents' gender*

As demonstrated in Table 6.1 as well as Figure 6.2 and 6.3, the distribution of gender in this survey was 73% (35/48) male and 27% female (13/48). All of the participants (48) stated their gender, based on which, they were split into 35/48 (73%) males and 13/48 (27%) females. The majority of the respondents were male. The percentage of females taking part (27%, 13/48) was of sufficient number to give a satisfactory reflection of their opinions, as seen in Figure 6.3.

Table 6.1 as well as Figure 6.2 show that the respondents were divided into 4 age categories. Variety in the ages of the respondents was sought in order to elicit a range of viewpoints as to design energy-efficient home considering Baghdad's climatic condition and culture. The largest age group interviewed (58%, 28/48) ranged from 40-60 years old from both genders. About 29% (14/48) belonged the age group more than 60 years old and the smallest group (13%, 7/48) was from ages less than 40 years old. This gives a good indicator that the respondents have had enough experience to judge in this study.

- **Academic education level**

All respondents (48) were asked the following question:

Q3: What is your qualification?		Master Degree
		Ph.D. Degree

The level of education is considered as an important aspect that may influence respondents' opinions towards architecture and housing conditions.

Table 6.2: *Acade`mic educational levels*

	Master Degree	Ph.D. Degree	Total	%
Decision Makers	5	12	17	35%
	29%	71%	100%	
Academics	0	16	16	33%
	0%	100%	100%	
Construction Industry practitioners	2	7	9	19%
	22%	78%	100%	
International	0	6	6	13%
	0%	100%	100%	
Total	7	41	48	
Percentage	15%	85%	100%	

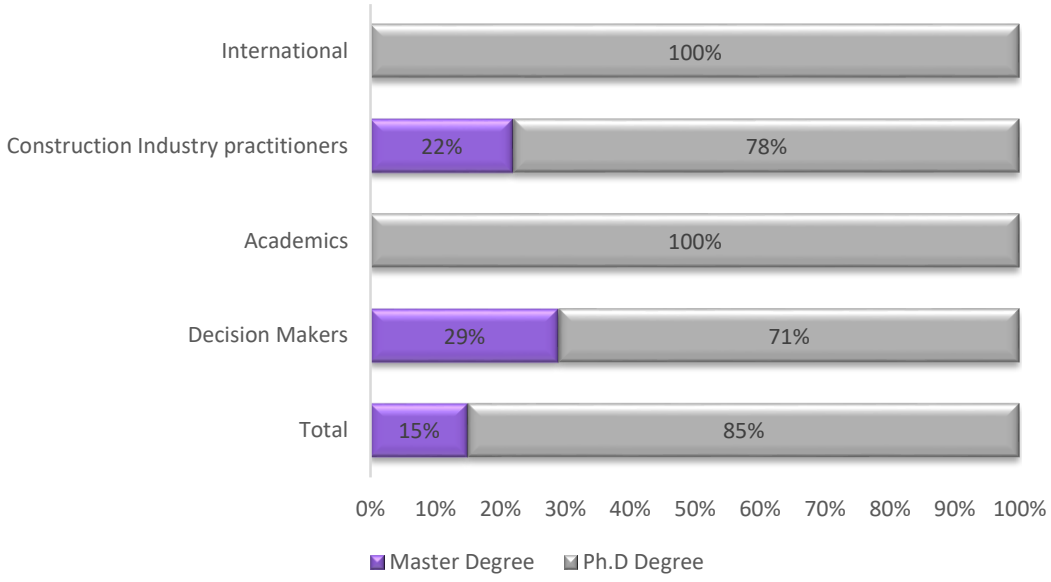


Figure 6.4: *Academic educational levels*

Table 6.2 and Figure 6.4 shows the education levels achieved by the respondents, divided into two main groups. The majority (85%, 14/48) hold a PhD degree, while 15% (7\48) have a Master degree. These qualification levels were considered to mean that the respondents were able to understand and judge the questions intellectually and relate them to their experiences.

6.2.2 Part B: Opinions on design and construction relating to bioclimatic design of contemporary housing for Baghdad

This phase presents the views of the 48 experts relating to existing contemporary houses and traditional vernacular components and potential barriers to their inclusion in new housing designs.

- **Opinions on issues facing Baghdadi's domestic built environments**

All the participant experts (48) were asked the following questions.

Q.4	In your perception, are there any issues with contemporary houses in Iraq? If yes, could you provide any solutions to these issues?

The main aim of this question is to gain insight into the perception, attitudes, and beliefs of the experts concerning the issues that face contemporary homes in Baghdad, Iraq. The purpose is to expose issues facing contemporary homes in Baghdad which can be addressed using vernacular features. The text responses were categorized into the following categories:

- Socio cultures:
- Environmental sustainability:
- Commercials;
- Heterogeneous design of house.

Table 6.3 illustrates the categories in relation to the responses.

Table 6.3: *Issues facing the contemporary Baghdadi houses*

Issues facing the Contemporary Baghdadi houses	Socio-Cultural	Environmental Sustainability	Commercial\ Government's role	Spatial	Total
Decision Makers	7	6	3	1	17
	41%	35%	18%	6%	100%
Academics	7	5	2	2	16
	44%	31%	13%	12%	100%
Construction Industry practitioners	3	4	1	1	9
	33%	44%	11%	11%	100%
International	2	2	1	1	6
	33%	33%	17%	17%	
Total	19	17	7	5	100%
Percentage	40%	35%	15%	10%	100%

Table 6.3 shows that all (100%, 48/48) respondents suggested problems being encountered by contemporary residential homes in Baghdad. The main categories of concern were 75% (36/48) to socio- cultural and environmental sustainability (Socio-cultural (40%, 19/48) and Environmental sustainability (35%, 17/48)). However, there were also concerns relating to commercial (15%, 7/48), and heterogeneous (10%, 5/48).

The consultations with the experts resulted in intense discussions into hypothetical, beliefs and practical perspective. This wider discussion is presented below within the same categories already discussed.

Socio-cultural: cultural challenges were found to be a significant concept from the expert consultation. A certain challenge that was prevalent in these interactions was the methods of improving these sociocultural aspects in residential homes using vernacular design and features.

E.5. +30: "For me, social aspects are very important and if we are just saying identity we may not see the other aspects of it like functionality. Social and behavioral aspects…I would look at a Rappaport model and his way of dissects through identity, social values, and looks at all these things".

E.10. +60: "I would advise a modern nationality to pay attention to cultural aspects. There is a range of sub-factor considerations under the socio-cultural category, while privacy can be seen as the overarching factor to be adopted in informing contextually appropriate domestic design… Regarding privacy to express our culture, the entrance (Mejaz) of the vernacular house provides their inhabitants with complete privacy when they use the habitable rooms and spaces even without overlooking or intrusion by visitors. Besides, when they use the courtyard for their daily activities the courtyard provides the inhabitants with complete privacy because the external walls are high enough to prevent overlooking by neighbors and passers-by. Further, the vernacular houses have been built in groups and this has further enabled the inhabitants of these houses to have a direct social connection between each other. However, in the modern house, the inhabitants and the visitors enter the house from the same entrance through the front open space (tarma) and the entrance hall directly to the inside of the house. This entrance does not provide the inhabitants with privacy. Therefore, the consideration of the entrance lobby (Mejaz) of the traditional house type could be applied to the future design strategies as the Mejaz provide the inhabitants with complete privacy".

E.6. +30: "Culture came from the needs of the people in their houses at that time. Now we have different needs but some of them are still the same, as have habitable rooms and spaces designed particularly to receive visitors, especially adult male visitors; these rooms could be a reception room at ground floor level and a (shanasheel) room in the upper floor level. Culturally this separation is important but at the same time, todays, the characteristics of the modern house do not respond to the cultural requirements for privacy. It depends on how comfortable are we in the house. Therefore, that such aspect could be not included in future design strategies".

E.26. +30: "The courtyard in vernacular house has satisfied the absolute need of the inhabitants for the socio-cultural factors. We miss important feature in current house and the concept of the courtyard would be useful in the future ideal house".

E.17. +60: "In past, people pay attention on socio-cultural aspects and it came from their needs. At that, time the traditional roof terrace an important socio-cultural requirement provides the

inhabitants with complete privacy when they used it for sleeping in the night during the summer. However, the modern roof terrace does not provide the inhabitants with complete privacy when they used it for sleeping in the night during the summer. Also the inhabitants of the vernacular house feel very secure in their roof terrace but has been found is the inhabitants of the modern house feel fairly insecure in their roof terrace".

E.3. +30: "Yes, but within this culture, we have different understandings. So I think design is personal there is something general but still personal".

The advent of industrialization and the oil boom brought about a remarkable transformation into the Iraqi society and developed a kind of tension between past and current socio-cultural schemes. For instance, there are two kinds of family events. They can either be separated according to their gender or probably just socialize together. In previous times, male and female from a larger family usually have lunch or socialize independently. This resulted in one of the comments that:

E.28. +30: "Before culture is more tradition and norms than religion…Today for family gatherings there are people who don't mind to have men and women together and others men and women seat in different areas. For me in part of my family we sit together and then for other gatherings we sit separately".

In-depth understanding of the different point of view and concepts of these experts was derived from these interactions as it relates to the vernacular design in Iraq and how this affects recent designs. One expert provided insights on the evolution of the built environment of Iraq and described it as being equally regional and local, *"In reference to time it responds to a certain period, the wood, the doors how they are made. There was cultural influence of different cities that we visited that represented the identity of the old houses. The trade in the sea, the people it represented"* (E.2. +30). Simultaneously outlining the reality that change occurred after the destruction of the old Baghdad city which interrupted the linkage between the past, current and future structural elements and architecture. The expert mentioned that:

"If we made a gradual change to these houses, but we actually destroyed the whole city. That horrible thing that made a break, the market had mud brick stone wood now its concrete you see

this it is not gradual and there is a disconnection in zoning. You can't see this gradual change" (E.32. +60).

Environmental Sustainability: Another idea that also emerged from the consultation with the experts was the several interactions that centered on the environmental aspects and challenges that should be resolved with different solutions being suggested. A certain challenge that was prevalent in these interactions was the methods of improving these environmental aspects in residential homes using vernacular design and features.

E.42, +35: "It's a shame that Baghdadi's feel the need to look to other cultures for inspiration and neglect their own. Space should be given for a courtyard, with open space and green trees, courtyard gives comfort and calmness for the individuals of the house. I think that we can really take a modern approach to inspire from vernacular design and make aesthetically and functionally successful design.".

E.4. +60: "Relaxing place to live in, close to the environment and the sky comfortable and original. The courtyard is a very pleasant space that we miss in our new house, the whole family comes together there, it is safe and the water element and vegetation makes the environment more pleasant".

E.3.-35: "In my opinion, vernacular houses are a step towards environmental sustainability. Better usage of space, more greenery and trees, more brightness".

These suggestions in the quote from the respondents clearly show the extent to which Baghdad's houses are valued. It also reveals the link between an individual's perspective with cultural and environmental impacts. These points of view reveal several but the same definitions each respondent have towards vernacular buildings. A few of the respondents had felt positive and others nostalgia which all points to how they personally view their homes. For instance, a participant connected the environment and the courtyard area with the aid of the local Sidra tree. *"The Sidra tree holds a lot of meaning for me personally. I grew up with it in my old grandpa's house and my cousins and I used to make up stories about what lived up in its big bushy canopy. Also, it was a modern house, the Sidra was a heritage that was preserved and the love of its heritage was passed down to me. The rest of the features are the features I admire, respect, and see depth in. However, I have never experienced them on a personal level except in theory. I would love to live in a house like that". (E.47. +30)*

Some experts even encourage the return of the vernacular features which was stated in the comments made by one of them.

E.8. +60: "The picture of any Iraqi house complete with a courtyard. It should be used in today's design; every house should have it. In addition, reducing electric consumption, to have the right insulations… the Mayoralty of Baghdad has to have a role or even the environmental protection agency… The house can have levels. I think that we can really take a modern approach to it and use the courtyard, as a vernacular feature, into a design that is aesthetically and functionally successful."

Commercial \Government's role: Another significant theme that was comprehensively evaluated by the experts during the consultation was the involvement of the government, which was characterized mostly by the "lack of foresight and vision" concerning recent design and developing environments in Baghdad, Iraq. When professionals were asked about their opinions about the challenges encountered by modern residential homes in Iraq, most of them stated that the government which is represented by the Mayoralty of Baghdad or the Ministry of Construction and Housing which has always been the problem but is also able to provide a solution.

E.18. +30: "The Mayoralty of Baghdad should have better regulation to begin with. It is already bad regulation."

E.15. +60: "It is a lot of corruption. Some sections (legislation) should not be there the Ministry of Construction and Housing with Mayoralty of Baghdad approved it and we didn't approve it as experts in the field."

Although, some of these experts placed the blame on individuals who do not abide by the regulations.

E. 21. +30: "The Mayoralty of Baghdad is not the problem the violations of the people is the problem."

This was observable by the experts and the development procedure. Some homeowners modified the design of their homes even after receiving their home licenses. This was described by one of the professionals and recognized this issue by stating:

E.26. +60: "I have an engineering office and the biggest challenge we have today is that the client says what can you do for me after I get permits of building and electric power. The first few years I was refusing to do that but now, you have the Mayoralty of Baghdad work and what ends up in reality. Now if we do not do it they will take the business somewhere else. The killer is when you say it is against the Mayoralty of Baghdad regulations. Moreover, when we go there, the Mayoralty of Baghdad manager says it's okay [Mr.] take your electricity and then cut all you want [change your design]".

Some of the experts also blamed the architects for just copying designs from external sources without creating a professional design for their customer.

E. 3. +60: "More and more of our houses are convention. It's not my private haven where I can settle down and enjoy. More and more of it is a factory that produces. More laws to go up to the sky. This phenomenon is increasing in far areas. They want to live next to their relatives and there is high demand … Who created this problem are the government, big private sectors, and real-estate owners. I support this move because they are from objective studies… If we continue, it will change the skylines and streets surrounded by cars instead of shops and pedestrians. Let people enjoy their streets".

A few of these professionals responded that the ancient regulations that do not follow recent trends and demands of the general public were the major reason behind these violations. They continually claim that recent regulations and real facts are interconnected. One of the experts indicated that:

E. 20. +30: "The violations are, as a result, of the bad codes of the Mayoralty of Baghdad and public demands. How should they [people] live?... Who has the right to choose how to live and how you want your house to be. There is a big communication rift between the Mayoralty of Baghdad and the public. People do not accept the codes as rules to follow strictly and as much as this is the way that we should live".

Moreover, the experts were asked about the possibilities of designing a model that can be used as a reference that can help architects when designing in the same circumstances. The majority of the interviewees welcome the idea of a typical model with consideration of the different views and needs. As one expert say:

E. 25. +60: "In my opinion, to design homes that are appropriate for the local climate, designers must fully understand the unique characteristics of the climate, as well as the availability and suitability of the building materials and resources".

Additionally, another point that was made by several experts was it could be useful to provide general strategic guidelines that include scientific facts that can be used as references to help architects when they are considering designing a house in Iraqis climatic conditions.

E. 43. +60:" The guideline can be described as zoning concepts which gives appropriate guidelines and leave the design to each architect to put in their views when implementing these guidelines. The design guidelines are sometimes seen as a control to designer's freedom, accordingly, the designers would often, therefore, resist such a control".

On the other hand, 42/48 of experts stated that it could design a flexible model, which could be used as guidance for designing houses that are located in the same climatic conditions.

However, different opinions about the Socio-cultural insights and the built environment, many of the experts believed that practical steps are required from the government in this aspect. The outlined interactions centered on the importance of having up to date regulations that will meet the latest demands and bring the deteriorating quality of the latest residential built environment back to life.

Spatial: A theme that is almost similar to culture and traditions is the significance of space in developed environments in Iraq. A very common remark that most of the experts stated were the importance of a larger space in today's world compared to the past. Space is connected to an individual's demand for modern luxurious facilities which is considered a necessity in this 21st century.

E.5. +30: "But the needs are different. The bedroom can hold three people before but now everyone wants their own room. Now they have many living rooms for guests of 200 people and they use it once a year."

E.2. +30: "Space, definitely more space. Before families would settle for a room or two now modern life facilities each family needs more space, such as maids room, so I would definitely say space".

Why would the demand for additional space be considered by these experts a challenge facing modern residential homes in Iraq? Could it be that this space is more of a luxury than a necessity which has resulted in wasted rooms, receptions and high cost of energy? This shows that these experts are perceptive about the significance of environmental sustainability in the modern residential developed habitat. Although, only a few of the experts described the derivable benefits of sustainability. One participants indicated that architectural designs are determined by the necessities which have been modified to meet the demands in the society. However, he also argued the need for an environmentally sustainable design in order to enjoy a comfortable life.

"Actually if we go back to the old past they designed based on their needs. They used mud because it is cooler. Now these days our requirements changed. It is designed to be more comfortable to needs than to be environmentally friendly. So I think in my view that's number one (E.45. +30)."

- **Apply vernacular features in contemporary or future dwellings**

All the participant experts (48) were asked the following questions.

Q.5	Do you think vernacular features should be used in the present or future Baghdadi dwelling? Why? What are the features?

The significance of these questions is to help identify the possible use of vernacular features in the future or contemporary designs. The participant's justification for the application of several vernacular features in homes is revealed in Table 6.4 and Figure 6.5.

Table 6.4: *Application of Traditional Vernacular Elements*

	Yes	No
Decision Makers	16/17	1/17
	94%	6%
Academics	14/16	2/16
	88%	12%
Construction Industry practitioners	6/9	3/9
	67%	33%
International	5/6	1/6
	83%	17%
Total	41/48	7/48
Percentage	85%	15%

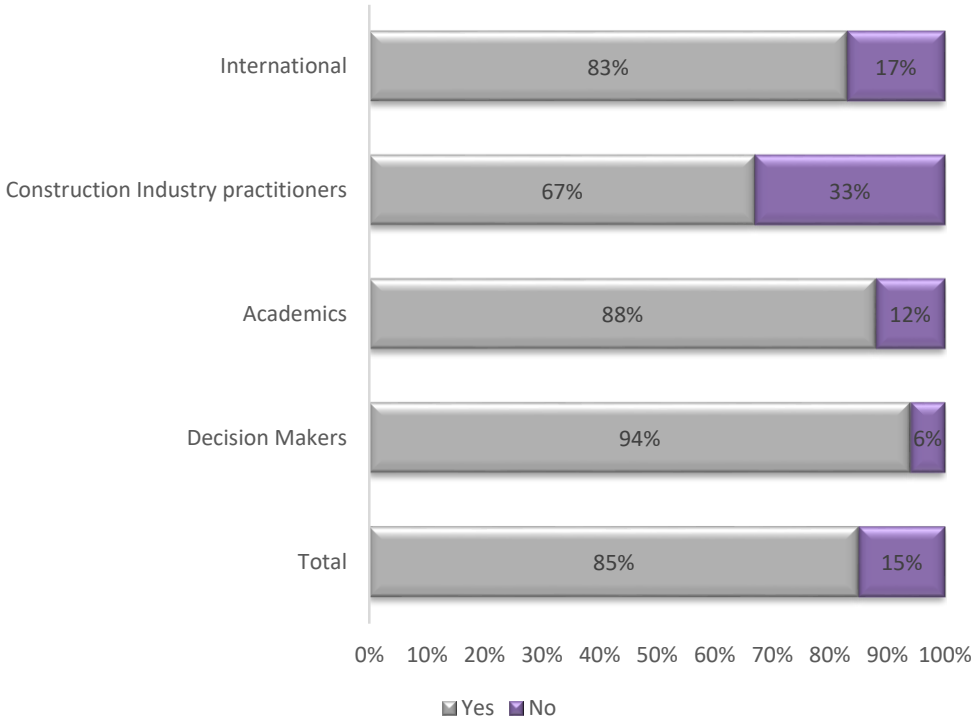


Figure 6.5: *Application of Traditional Vernacular Elements*

Table 6.4 and Figure 6.5 show that 85% (41/48) of participants answered yes, while 15 % (7/48) answered no. The reasons behind these ratings given by the experts are analysis and summaries in Table 6.5, as follows:

Table 6.5: *Participant reasons for applying vernacular elements.*

Reasons	Socio-Cultural	Environmental Sustainability	If Adaptable	Functional	Aesthetics	Total
Decision Makers	5	4	3	5	0	17
	29%	24%	18%	29%	0%	100%
Academics	5	5	3	2	1	16
	31%	31%	19%	12%	17%	100%
Construction Industry practitioners	2	2	3	1	1	9
	22%	22%	33%	11%	11%	100%
International	3	2	1	0	0	6
	50%	33%	17%	0%	0%	
Total	15	13	10	8	5	48
Percentage	31%	27%	21%	17%	10%	100%

Table 6.5 shows that 15 of the 48 participants which 31% gave these answers due to socio-cultural reasons. Environmental sustainability was the second reason 13 out of 48 which is 27% as the cause of applying the vernacular features. The last three categories are functionality 8/48 (17%), adaptability 10/48 (21%) and aesthetics 2/48 (4%).

The majority of experts agreed that vernacular architecture had provided very good solutions in the past and had proved its suitability to the climate. They confirmed that if features from vernacular houses were developed and used in a suitable way it could well help in improving future houses and in providing a special local identity. They also pointed out the importance of convincing people to accept these ideas. Only the courtyard received a highest percentage, which indicates that it was likely that the experts apply these conventional vernacular features in their recent or future dwellings.

Many of these expert's recognized the significance of vernacular design features and how critical it is in bringing together the family.

E.27. +30: "The house before what did it have? It had its courtyards, and with many services. Secondly, the idea of having people's children live with them is an old understanding. Now everyone is going further away and that is wrong. Moreover, if you go to south of Iraq till this day their children are living with their fathers and mothers (also after married)".

E.30. +30: "Today the children they may have an apartment within the house and they can close the door and may have privacy more than when he stayed in his father's house before. Also fascinating is the relationship between the family sphere and privacy and how it relates to the traditional vernacular. Therefore, privacy was between one family to the other but not within the family".

E.44. +60: "Now I see houses with people all over the place but my sister I don't see because she has a whole flat and I have my own but if we go back to the old designs we would have roof. Yes, I know we will have problems with privacy but I will see my sister that is more important".

Many of the experts came up with various points of view during the consultation. With the knowledge of the importance of these elements, most experts still argued the fact that it should be integrated with the modern residential structures in Iraq. The professional background of these experts is revealed with this level of knowledge and this indicated that these professionals had different perspectives which were expressed in the consultation. One expert (+60) stated that vernacular features should be considered beyond just a decorative feature which he then described as: "*we should think of not only the physical manifestations of these elements but also the functional aspects. How it worked for us in the past*" (E.13. +60).

Generally, the experts identify the significance of the vernacular features, however, not every one of them knows how or if they ought to be assimilated into the residential housing units in Iraq. One expert suggested that: *"we can integrate some elements but not all elements. We cannot put some elements with modern designs we just cannot… Do we need the courtyard in the middle of the house or outside its different?" (E.7. +30).*

The experts recognized three main features which are the courtyard, the Liwan, and the Shanasheel. This indicates that participants will more than likely use them.

- **Significant aspects in participants' homes**

All the participant experts (48) were asked the following questions.

Q.6	Which of the following factors do you aspire to have significance in your house: Culture, Identity, Modernity, Environment sustainability or any other? Rank them, please.

Subsequent to collecting various opinions, views, and attitudes about the challenges encountered in contemporary residents in Baghdad, Iraq. The third question investigated the most important aspects of homes from the options of: culture, identity, modernity, and environmental sustainability. This closed question was intended to generate insights and provide context for other questions.

The ranking of these factors was done using a highest ranking. The respondents rank of these factors and the level of importance was calculated. The highest number of points is allocated to the highest factor which is then summed over all participant responses to evaluate the overall level of importance.

The factor of importance in the home of the respondent is revealed in Table 6.6.

Table 6.6: *The factor of importance in the home of the respondent*

Reasons	**Environmental Sustainability**	**Identity**	**Culture**	**Modernity**	**Total**
Decision Makers	6	5	5	1	17
	35%	29%	29%	6%	100%
Academics	6	6	2	2	16
	38%	38%	12%	12%	100%
Construction Industry practitioners	3	2	1	3	9
	33%	22%	11%	33%	100%
International	2	2	1	1	6
	33%	33%	17%	17%	
Total	17	15	9	7	48
Percentage	35%	31%	19%	15%	100%

Table 6.6 shows that the experts gave environmental sustainability the highest percentage (35%, 17/48) overall, closely followed by "identity" which was ranked second (31%, 15/48). The last two categories were culture 19% (9/48), and modernity 15% (7/48). This ranking is presented in Table 6.6.

- **Including Vernacular features in house design**

All the participant experts (48) were asked the following questions.

Q.7	Do you include vernacular features in the homes design? If yes or no, why?

This question was asked in order to investigate if experts included vernacular elements in their designs. Table 6.7 shows the descriptive statistics of use of vernacular features in expert's designs.

Table 6.7: *Application of Vernacular Features*

	Yes	**No**	**Total**
Decision Makers	13	4	17
	76%	24%	100%
Academics	8	8	16
	50%	50%	100%
Construction Industry practitioners	3	6	9
	33%	67%	100%
International	4	2	6
	67%	33%	100%
Total	28	20	48
Percentage	58%	42%	100%

Table 6.7 shows that 28 out of the 48 experts (58%) showed that some kind of vernacular features were present in their current or past house designs, and 20 of the 48 experts (42%) did not. 18 of them claimed to use courtyards, stating that the external space was *"environmentally friendly"* as well as *"socially efficient"*. The "*Liwan'* was used by three experts, but the *"wooden door, parapet wall*, and the *Shamasheel"* were only mentioned once.

Some of the experts that showed no involvement with vernacular features in their present or past dwellings, justified this by mentioning that *"Iraqi's current building laws don't encourage such concepts"* and that it is *"not required by most clients… our fault for not encouraging its use"*. While other experts mention that, there is *"no need for it"* and *"modern design can't include vernacular elements"*.

- **Issues prevent from adding a vernacular element**

All the participant experts (48) were asked the following questions.

Q.8	Do you believe there are issues that may prevent from adding a vernacular element in current or future house?

The objective of the question is to find the issues which might hinder experts from including a vernacular feature such as a courtyard in their modern or future home design.

Table 6.8 shows the present the issues that can hinder experts from using vernacular features in house design.

Table 6.8: *Issues preventing the use of vernacular features in modern house designs*

Issues	High real-estate prices	Iraqis, Baghdadis, housing crisis	Having a small plot of land	Lack of government regulation to promote vernacular	Increasing user requirements	Total
Decision Makers	5	6	2	3	1	17
	29%	35%	12%	18%	6%	100%
Academics	3	3	7	2	1	16
	19%	19%	44%	12%	6%	100%
Construction Industry practitioners	3	2	1	1	2	9
	33%	22%	11%	11%	22%	100%
International	2	1	0	2	1	6
	33%	17%	0%	33%	17%	
Total	13	12	10	8	5	48
Percentage	27%	25%	21%	17%	10%	100%

Table 6.8 shows the different problems identified from the experts' consultation. These are: having a small plot of land, high real-estate prices, the housing crisis in Iraqi / Baghdad, lack of government regulations to promote vernacular elements, and increasing user requirements. It is worth mentioning that Baghdad's current housing crisis (25%, 12/48) is one of the main reasons and is also associated with other key barriers - the high real estate prices (27%, 13/48) and the restriction to a small plot of land (21%, 10/48) as well as the lack of government regulation to promote vernacular elements (17%, 8/48). The remaining barrier was the increasing user requirements (a smaller barrier (10%, 5/48)).

- **Designing a special architectural model with special specifications appropriate to the particular region and climate**

All the participant experts (48) were asked the following questions.

Q.9	Do you think there are possibilities of designing a model that can use as a reference to help architects when designing in the same circumstances?

This question was asked in order to investigate the possibilities of designing a model that can be used as a reference that can help architects when designing in the same circumstances. Table 6.9 shows the possibilities of designing a reference model that can help architects when designing in the same circumstances.

Table 6.9: *Possibilities of designing a reference model*

	Yes	**No**	**Total**
Decision Makers	16	1	17
	94%	6%	100%
Academics	14	2	16
	88%	12%	100%
Construction Industry practitioners	7	2	9
	78%	22%	100%
International	5	1	6
	83%	17%	100%
Total	42	6	48
Percentage	88%	12%	100%

Table 6.9 shows that 88% (42/48) of participants answered yes, while 12 % (6/48) answered no. The majority (88%, 42/48) of the experts welcome the idea of the reference model with consideration of the different views and needs.

In order to design homes that are suitable for the local climate, designers must fully realize the unique climate characteristics, in addition to the suitability and availability of the building materials. Additionally, it could be useful to provide general strategic guidelines that include scientific facts that can be used as references to help architects when they are considering designing a house in Iraqis climatic conditions.

Some experts mention that the guideline can be described as zoning concepts, which gives appropriate guidelines and leave the design to each architect to put in their views when implementing these guidelines. one expert was in agreement with the statement, *"the design guidelines are sometimes seen as a control to designer's freedom, accordingly, the designers would often, therefore, resist such a control*". On the other hand, 17 of experts stated that they could design a flexible model, which could be used as guidance for designing houses located in the same climatic conditions.

The experts thought that the following elements should exist in a best housing model: it should include sustainable housing concepts, provide for people's needs, offer comfort, safety and beauty and should help in reducing energy consumption. Moreover, some experts stated that the best model should respect building laws and consider the need for thermal resistance, use technology and developed building materials, vernacular architectural features such as the courtyard concept with some modifications, and use badgir and shanasheel.

6.2.3 Part C: Opinions on efficient solutions to reduce energy demand of houses

This section presents the views of the 48 experts on the efficient solutions that reduce energy demand in the domestic building.

- **Expert's opinions on building design techniques and procedures**

48 respondents were asked to rank the aspects in Table below from 1 to 5 (1 being least important and 5 being the most important).

- **Massing and space layout**

The experts ranked aspects relating to massing and space layout based on the probability of it reducing energy demand in the domestic building.

All respondents (48) were asked the following question:

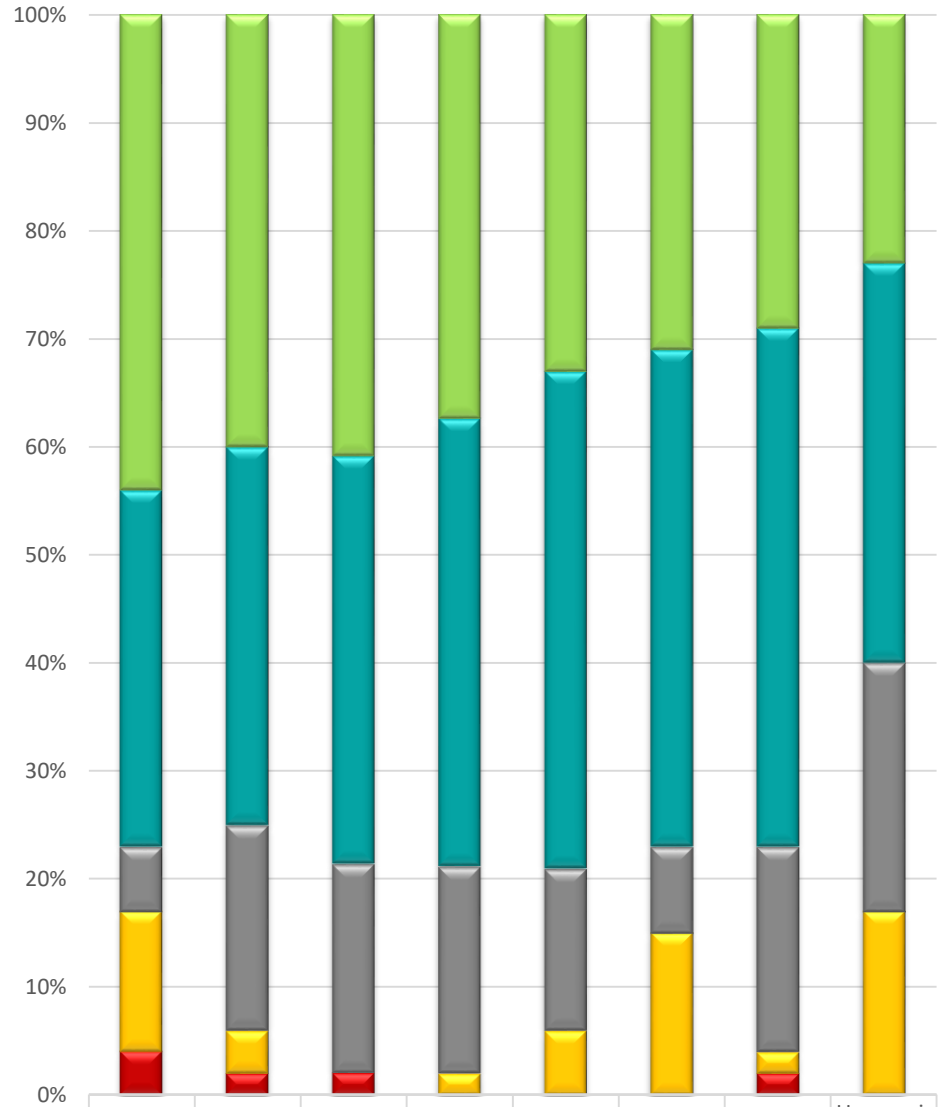
Q.10	The building's structure is important when looking to use energy efficiently. Look at each option below and rank your views on which would save energy the most and which the least.					
		1. Not important	**2. least important**	**3. Neutral**	**4. Important**	**5. Extremely important**
	A: Buildings orientations (south facing)					
	B: Shading device					
	C: Minimizing building size as possible					
	D: Shape of building					
	E: Internal subdivisions					
	F: Using Green buildings techniques					
	G: Slope shape to minimize exposure sun heat					
	H:Use semi-detached or terraced house configuration					

The percentage of responses for each ranking level, the calculated mean ranking and interquartile range are all presented in Table 6.10. While the distribution of ranking is shown in Figure 6.6.

Table 6.10 : *The average results of the importance of mass and space layout*

Massing and space layout		Total	%	Mean	*IQR
A:Orientation of the building (south-north facing)	Not important	1	2%	**4.02**	**1**
	Less important	1	2%		
	Neutral	9	19%		
	Important	23	48%		
	Extremely important	14	29%		
B: Shading device	Not important	1	2%	**4.08**	**1**
	Less important	2	4%		
	Neutral	9	19%		
	Important	17	35%		
	Extremely important	19	40%		
C: Minimizing building size as possible	Not important	2	4%	**4.02**	**1**
	Less important	6	13%		
	Neutral	3	6%		
	Important	16	33%		
	extremely important	21	44%		
D: Optimal design of building shape	Not important	0	0%	**4.06**	**1**
	Less important	1	2%		
	Neutral	9	19%		
	Important	20	41%		
	Extremely important	18	37%		
E: Internal subdivisions of the building	Not important	1	2%	**4.08**	**1**
	Less important	0	0%		
	Neutral	9	19%		
	Important	18	37%		
	Extremely important	19	40%		
F:Using Green buildings techniques	Not important	0	0%	**3.96**	**1**
	Less important	3	6%		
	Neutral	7	15%		
	Important	22	46%		
	extremely important	16	33%		
G:Slope shape to minimize exposure sun heat	Not important	0	0%	**3.86**	**1**
	Less important	7	15%		
	Neutral	4	8%		
	Important	22	46%		
	extremely important	15	31%		
H:Use semi-detached or terraced house configuration	Not important	0	0%	**4.02**	**1**
	Less important	8	17%		
	Neutral	11	23%		
	Important	18	37%		
	Very important	11	23%		

*IQR: The interquartile range



	Minimizing building size as possible	Shading device	Internal subdivisions of the building	Optimal design of building shape	Using Green buildings techniques	Slope shape to minimize exposure sun heat	Orientation of the building (south-north facing)	Use semi-detached or terraced house configuration
Very important	44%	40%	40%	37%	33%	31%	29%	23%
Important	33%	35%	37%	41%	46%	46%	48%	37%
Neutral	6%	19%	19%	19%	15%	8%	19%	23%
Less important	13%	4%	0%	2%	6%	15%	2%	17%
Not important	4%	2%	2%	0%	0%	0%	2%	0%

Figure 6.6 :*Massing and space layout: Percentages given by experts*

When putting up a building, many factors need addressing such as what the customer wants, the surroundings outside and the actual structure. Baghdad has extreme humidity and buildings need to prepared in such a way to reduce the intake of energy.

Such factors are, designing the inside, its overall effective appearance and creating areas of shade around the building. The results are shown in Figure 6.6 in relation to mass and layout. The results show that in order to minimize the utilisation of air conditioning units and reducing energy, the outside of the building is vital in providing shaded areas and coolness.

Table 6.10 and Figure 6.6 show the ranking results. All of the proposed items had strong support (60-79% of responses ranked as important or very important).

As shown in (Table 6.10 and Figure 6.6), the experts agreed upon the fact that the orientation of the building is an important aspect that needs to be consider. The experts believe that the building orientation must be directed towards south-north to gain the potential solar energy in the heating season. As far as the shading devices are concerned, the Table 6.10 and Figure 6.6 indicate that 75% (36/48) of the respondents have a perception that it is important (35%, 17/48) and very important (40%, 19/48) to have. It is probably due to the fact that shading devices prevent or reduce direct sunlight entering the space.

77% (37/48) of the respondents believe that it is best to reduce the size of the building. However, as far as the shape of building is concerned there is a need of optimal designs as important by 78% (38/48) of the respondents, who consider it very important (37%, 18/48) or important aspect (41%, 20/48), (Table 6.10 and Figure 6.6).

Additionally, the majority of the people questioned are of the same opinion that it is essential to consider the internal subdivisions of the buildings. While using green buildings techniques and opting for slope shape to minimize sun heat is also very critical to the building planning and design. While 77% (37/48) of the respondents have a perception that it is important (46%, 22/48) and very important (31%, 15/48) to opt for the slope shape, the 60% (29/48) of the respondents for the semi-detached or terrace house configuration. Hence, upon comparison, it can be duly noted that the majority population picks a shading device and internal subdivision of the building as an effective.

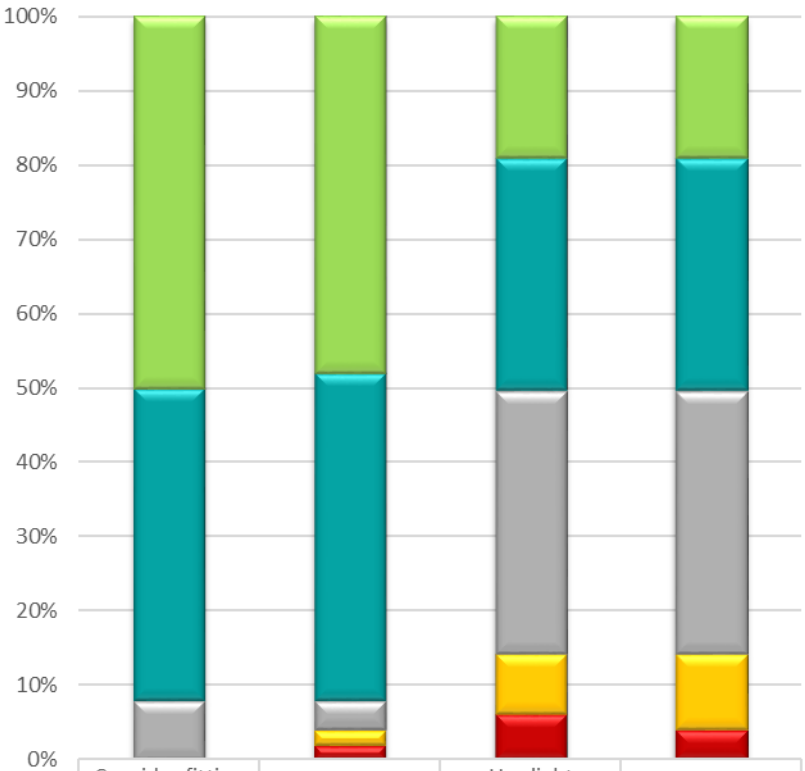
Participants had suggested further options for exploration in the topic of "massing and space layout":

- Increase green area around the building
- Use light colours for walls and roofs to reflect the heat of the sun
- Building structure considering the direction of the wind
- Taking the buildings surroundings into account

These aspects were ranked by the experts as for the previous batch. The rankings are presented in Table 6.11 and Figure 6.7.

Table 6.11 : *Massing and space layout: Suggestions for further techniques by the experts*

Massing and space layout		Total	%	Mean	IQR
I: Increase green area around the building	Not important	2	4%	**3.5**	**1**
	Less important	5	10%		
	Neutral	17	35%		
	Important	15	31%		
	Very important	9	19%		
J: Use light colours for walls and roofs to reflect the heat of the sun.	Not important	3	6%	**3.48**	**1**
	Less important	4	8%		
	Neutral	17	35%		
	Important	15	31%		
	Very important	9	19%		
K: Building structure considering the direction of the wind	Not important	1	2%	**4.33**	**1**
	Less important	1	2%		
	Neutral	2	4%		
	Important	21	44%		
	Very important	23	48%		
L: Taking the buildings surroundings into account	Not important	0	0%	**4.416**	**1**
	Less important	0	0%		
	Neutral	4	8%		
	Important	20	42%		
	Very important	24	50%		



	Consider fitting the building within its surrounding context	Design the building to take wind direction into account	Use light colours for walls and roofs to reflect the heat of the sun.	Increase green area around the building
Very important	50%	48%	19%	19%
Important	42%	44%	31%	31%
Neutral	8%	4%	35%	35%
Less important	0%	2%	8%	10%
Not important	0%	2%	6%	4%

Figure 6.7 :*Massing and space layout: ranking of additional options recommended by the experts*

Although there was more than 50% support for all options suggested, the lowest support was noted for:

- Increasing green area around the building.
- Using light colours for walls and roofs to reflect the heat of the sun.

While the highest support was for:

- Designing the building taking account of wind direction.

- **Window design**

Using the same ranking approach as described previously, all respondents (48) had been asked the following question:

Q.11	Which of the below would you say minimizes the demand for energy in household buildings.					
		1. Not important	**2. Less important**	**3. Neutral**	**4. Important**	**5. Very important**
	A:smaller windows					
	B: Reduce the number of windows					
	C: shelter the windows by the use of					
	D: plant agriculture at each window					

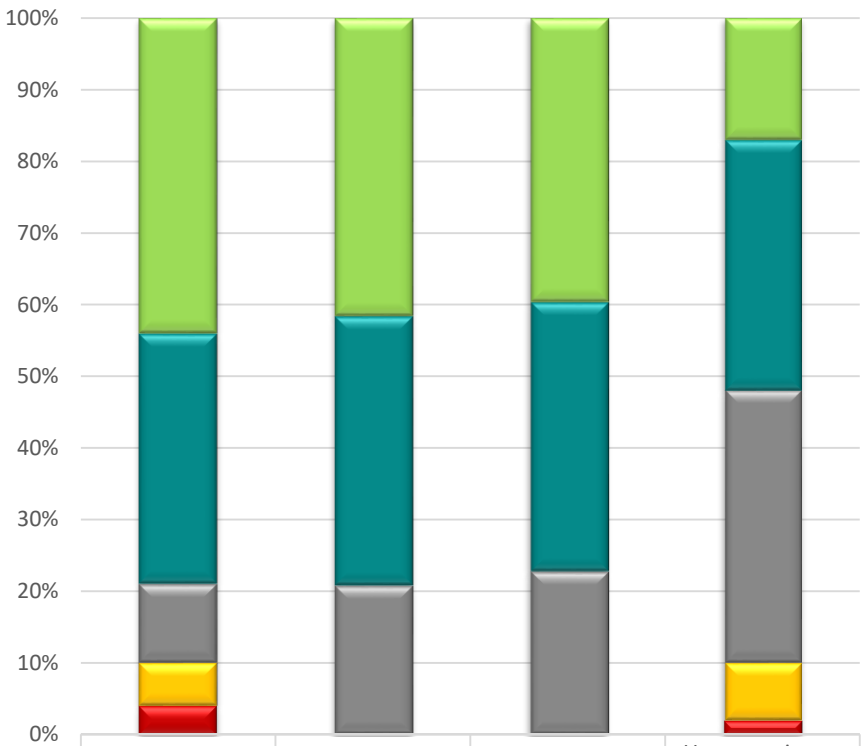
The window design is yet another crucial aspect of the building that architects needs to be considerate about. The windows are the vital source of light, warmth and ventilation within the building and thus its design is crucial to the architects (Alsteris & Paliwal, 2004).

It is a key feature for reducing solar gains and thereby reducing energy consumption. However, a conflicting desire is to provide natural light at the same time. Experts were consulted to give their opinions in the way that windows were put into buildings to save energy (see Table 6.12 and Figure 6.8).

The percentage of responses for each ranking level, the calculated mean ranking and interquartile range are all presented in Table 6.12. While the distribution of ranking is shown in Figure 6.8.

Table 6.12: *Window constructions and methods, respondents average results*

Window design		Total	%	Mean	IQR
A: Reduce windows area	Not important	2	4%	**4.27**	**1**
	Less important	3	6%		
	Neutral	5	11%		
	Important	17	35%		
	Very important	21	44%		
B: Reduce the number of windows	Not important	0	0%	**4.16**	**1**
	Less important	0	0%		
	Neutral	11	23%		
	Important	18	38%		
	Very important	19	40%		
C: shelter the windows by the use of canopies	Not important	1	2%	**3.56**	**1**
	Less important	4	8%		
	Neutral	18	38%		
	Important	17	35%		
	Very important	8	17%		
D: Use color glaze for external windows	Not important	0	0%	**4.208**	**1**
	Less important	0	0%		
	Neutral	10	21%		
	Important	18	38%		
	Very important	20	42%		



	Reduce windows area	Use color glaze for external windows	Reduce the number of windows	Use canopies on top of windows to prevent the sun heat
Very important	44%	42%	40%	17%
Important	35%	38%	38%	35%
Neutral	11%	21%	23%	38%
Less important	6%	0%	0%	8%
Not important	4%	0%	0%	2%

Figure 6.8: *Strategies and design techniques for windows: Percentages obtained from professionals*

While gathering a collective response on the design of window, it was noted that majority (79%, 38/48) of the sample respondents agrees upon the factor that the windows area should be reduced, while significantly decreasing the number of windows in the building. Additionally, 52% (25/48) of the sample respondents reflects that it is important (17%, 8/48) and extremely important (35%, 17/48) to have canopies attached to each window to protect from the sun (Table 6.12 and Figure 6.8).

It was also asked from the participants whether it is necessary to use colour glaze for external window or not. The response indicated that 80%(38/48) of the sample

respondents thinks that it is important (38%, 18/48) and very important (42%, 20/48), while 0% (0/48) of the respondents agrees to the fact that it is not at all important (Table 6.12 and Figure 6.8).

The results indicate that having smaller and less windows are vital to reduce the amount of heat that will go inside the building and therefore this will protect energy.

Participants had suggested further options for exploration in the topic of "Window design":

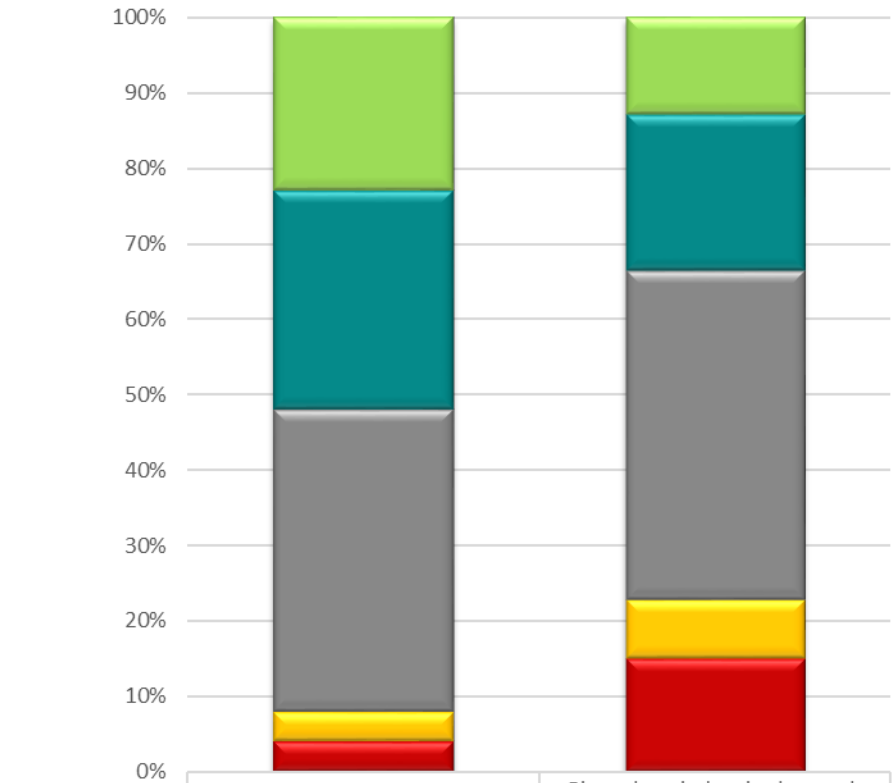
E: Grow grass in front of each window

F: build window facing north, collect solar energy from the south

These aspects were ranked by the experts as for the previous batch. The rankings are presented in Table 6.13 and Figure 6.9.

Table 6.13 *Window design techniques and strategies: Suggestions for further techniques by the experts*

Window design		**Total**	%	**Mean**	**IQR**
E: Grow grass in front of each window	Not important	2	4%	**3.625**	**1**
	Less important	2	4%		
	Neutral	19	40%		
	Important	14	29%		
	Very important	11	23%		
F: place the window facing north, collect solar energy from the south	Not important	7	15%	**3.04**	**1**
	Less important	4	8%		
	Neutral	21	44%		
	Important	10	21%		
	Very important	6	13%		



	Grow grass in the front of each window	Place the window in the north side, with solar collection in the south face
Very important	23%	13%
Important	29%	21%
Neutral	40%	44%
Less important	4%	8%
Not important	4%	15%

Figure 6.9 : *Window design techniques and strategies: Suggestions for further techniques by the experts*

Although there was more than 50% support for all options suggested, the lowest support was noted for:

- Grow grass in front of each window
- Build window facing north, collect solar energy from the south

While the highest support was for:

- Grow grass in front of each window

- **Shading device design and strategies**

Using the same ranking approach as described previously, all respondents (48) had been asked the following question:

Q.12	**Shading device:** Read each option below to decide which ones are most effective in reducing energy					
		1. Not important	**2. Less important**	**3. Neutral**	**4. Important**	**5. Very important**
	A: Use high shad device around building on top of external walls					
	B: Use effective courtyard landscape design to provide shade around the building					
	C: Use sun louver techniques.					
	D: using nature such as large trees to protect the home and provide protection from the sun					

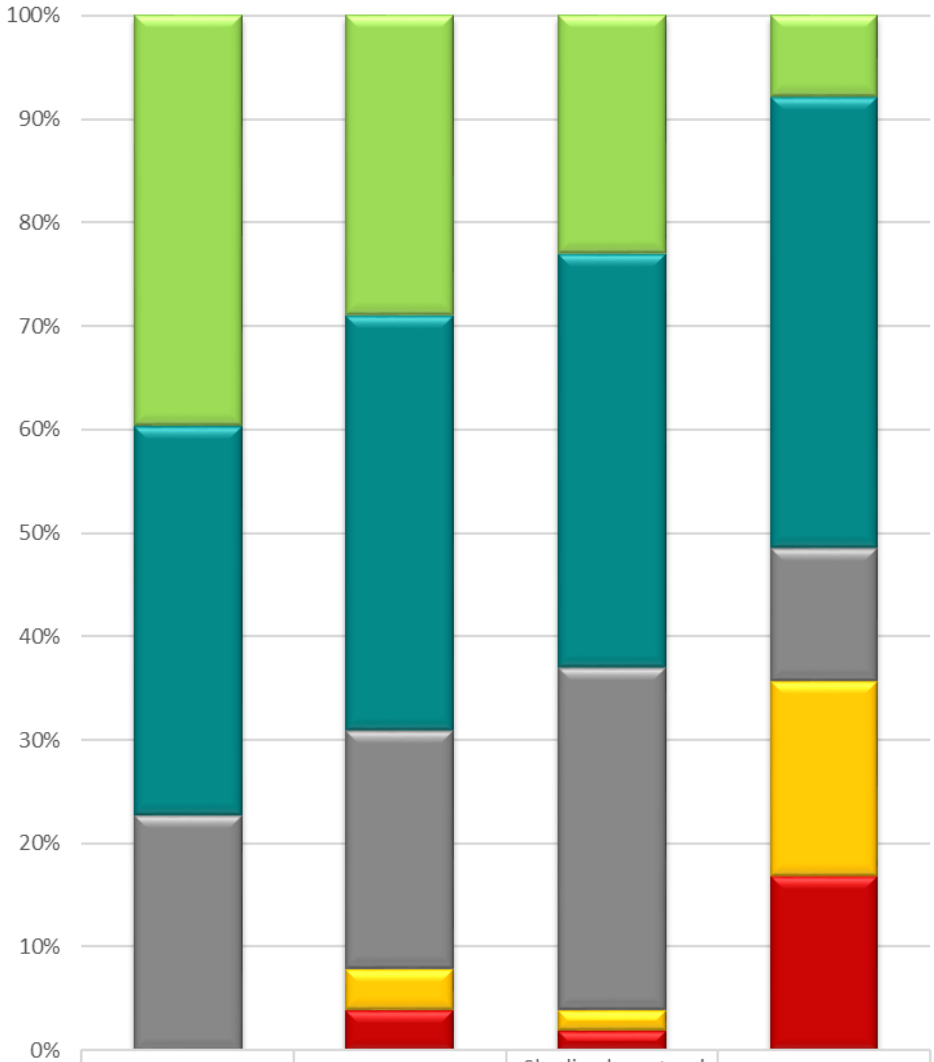
The shading devices or the light shelves are used as reflectors that can optimize the solar energy as required. However, to use shading it is essential to consider some of the aspects that can regulate the reach of the sunlight and the heat as well. The survey taken indicates the aspects of shading devices that needs to be considered (El-Refaie, 1987).

The use of shading devices is essential in warm countries. This is because it protects the outer building by keeping it cool which in turn reduces the use of air conditioners.

The percentage of responses for each ranking level, the calculated mean ranking and interquartile range are all presented in Table 6.14. While the distribution of ranking is shown in Figure 6.10.

Table 6.14: *Results from the panel for the different ways of shading the home inside and out*

Shading device		Total	%	Mean	IQR
A: Use high shad device around building on top of external walls	Not important	8	17%	**3.08**	**1**
	Less important	9	19%		
	Neutral	6	13%		
	Important	21	44%		
	Very important	4	8%		
B: Use effective courtyard landscape design to provide shade around the building	Not important	0	0%	**4.16**	**1**
	Less important	0	0%		
	Neutral	11	23%		
	Important	18	38%		
	Very important	19	40%		
C: Use sun louver techniques.	Not important	2	4%	**3.85**	**1**
	Less important	2	4%		
	Neutral	11	23%		
	Important	19	40%		
	Very important	14	29%		
D: using nature such as large trees to protect the home and provide protection from the sun	Not important	1	2%	**3.79**	**1**
	Less important	1	2%		
	Neutral	16	33%		
	Important	19	40%		
	Very important	11	23%		



	Use effective courtyard landscape design to provide shade around the building	Use sun louver techniques.	Shading by natural means (e.g. via trees) reduces the radiation entering adjacent buildings and the effects of wind.	Use high shad device around building on top of external walls.
Very important	40%	29%	23%	8%
Important	38%	40%	40%	44%
Neutral	23%	23%	33%	13%
Less important	0%	4%	2%	19%
Not important	0%	4%	2%	17%

Figure 6.10: *Results from the panel for the different ways of shading the home inside and out*

Table 6.14 and Figure 6.10 show that the majority of the panel gave importance to all of the ways of creating shade.

The respondents when enquired indicated that it is not that important to use high shade device on top of the building, instead a large portion of sample population agreed upon the fact that it is beneficial to use courtyard landscape design, which is much more effective. Moreover, 69% (33/48) of the participants responded that it is very important (29%, 14/48) and important (40%, 19/48) to use sun louver techniques, while 63% (30/48) of the respondents considered that the shading by natural means is also an effective solution.

The results underline that it is vital for buildings in Baghdad to have some sort of cover mechanism to protect the buildings from the sun. The upstairs are generally hotter and therefore needs cooling more than other parts of the building. The results from the panel, suggest that having some sort of cover on the highest part of the home would work in achieving this. This will in turn minimize the use of air conditioners as well as minimizing energy usage

Participants had suggested further options for exploration in the topic of "shading device":

E: Use horizontal canopy to create shade.

F: Shading in Ventilated Facades.

H: Use sun reflection design techniques.

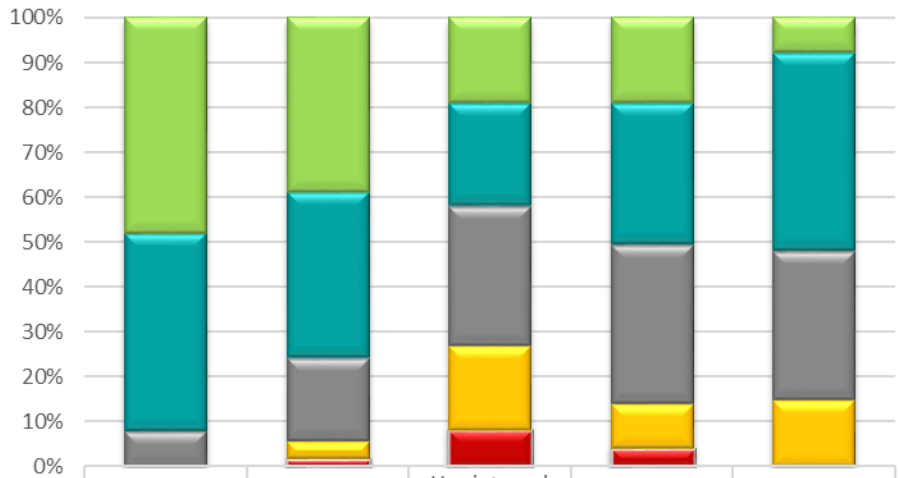
J: use covers on the inside and outer windows to stop sun from going inside the building.

K: Use roof shading techniques.

These aspects were ranked by the experts as for the previous batch. The rankings are presented in Table 6.15 and Figure 6.11.

Table 6.15:*Shading device techniques and strategies: Suggestions for further techniques by the experts*

Shading device		**Total**	**%**	**Mean**	**IQR**
E: Use horizontal canopy to create shade	Not important	2	4%	**3.5**	**1**
	Less important	5	10%		
	Neutral	17	35%		
	Important	15	31%		
	Very important	9	19%		
F: Shading in Ventilated Facades	Not important	1	2%	**4.06**	**1**
	Less important	2	4%		
	Neutral	9	19%		
	Important	18	38%		
	Very important	19	40%		
H: Use sun reflection design techniques	Not important	0	0%	**3.458**	**1**
	Less important	7	15%		
	Neutral	16	33%		
	Important	21	44%		
	Very important	4	8%		
J: use covers on the inside and outer windows to stop sun from going inside the building	Not important	4	8%	**3.95**	**1**
	Less important	9	19%		
	Neutral	15	31%		
	Important	11	23%		
	Very important	9	19%		
K: Use roof shading techniques	Not important	0	0%	**4.39**	**1**
	Less important	0	0%		
	Neutral	4	8%		
	Important	21	44%		
	Very important	23	48%		



	Use roof shading techniques	Shading in Ventilated Facades	Use internal and/or external shutter for windows to prevent unwanted solar gains	Use horizontal canopy to create shade	Use sun reflection design techniques
Very important	48%	40%	19%	19%	8%
Important	44%	38%	23%	31%	44%
Neutral	8%	19%	31%	35%	33%
Less important	0%	4%	19%	10%	15%
Not important	0%	2%	8%	4%	0%

Figure 6.11: *Shading device techniques and strategies: Suggestions for further techniques by the experts*

Although there was more than 50% support for all options suggested, the lowest support was noted for:

- Use horizontal canopy to create shade;
- Shading in Ventilated Facades;
- Use sun reflection design techniques;
- Use covers on the inside and outer windows to stop sun from going inside the building;
- Use roof shading techniques.

While the highest support was for:

- Use roof shading techniques;
- Use covers on the inside and outer windows to stop sun from going inside the building;
- Use sun reflection design techniques.

- **Cooling and heating systems (HVAC):**

Using the same ranking approach as described previously, all respondents (48) had been asked the following question:

Q.13	**HVAC:** Look at each option below and decide how important each one is in relation to cooling to save energy.					
		1. Not important	2. Less important	3. Neutral	4. Important	5. Very important
	A: Have smaller rooms so that the heating/cooling systems are only used when in that room. Therefore, energy is not wasted.					
	B:use sensors that will keep the rooms at a comfortable degree by the use of the air conditioner					
	C:Use mechanical ventilation techniques					
	D:Use ground heat exchange techniques					

In order to offer indoor comfort and breathable air in the home, it is essential to consider the efficacy of the HVAC system. The system exchanges or replaces air inside the building and gets rid of humidity, smells and enables easy breathing for better comfort in the extreme weather (Schneider, 2001). The demand for these systems are needed in cities like Baghdad all through the year.

Table 6.16 and Figure 6.12 show the expert's views, in round 1, different ways of minimising energy in homes in Iraq, Baghdad.

Table 6.16: *HVAC techniques and strategies: Percentages given by experts*

HVAC		Total	%	Mean	IQR
A: Have smaller rooms so that the heating/cooling systems are only used when in that room. Therefore, energy is not wasted.	Not important	2	4%	**4.08**	**1**
	Less important	1	2%		
	Neutral	7	15%		
	Important	18	38%		
	Very important	20	42%		
B: use sensors that will keep the rooms at a comfortable degree by the use of the air conditioner	Not important	2	4%	**4.16**	**1**
	Less important	2	4%		
	Neutral	4	8%		
	Important	17	35%		
	Very important	22	46%		
C: Use mechanical ventilation techniques	Not important	9	19%	**3.96**	**1**
	Less important	2	4%		
	Neutral	12	25%		
	Important	16	33%		
	Very important	9	19%		

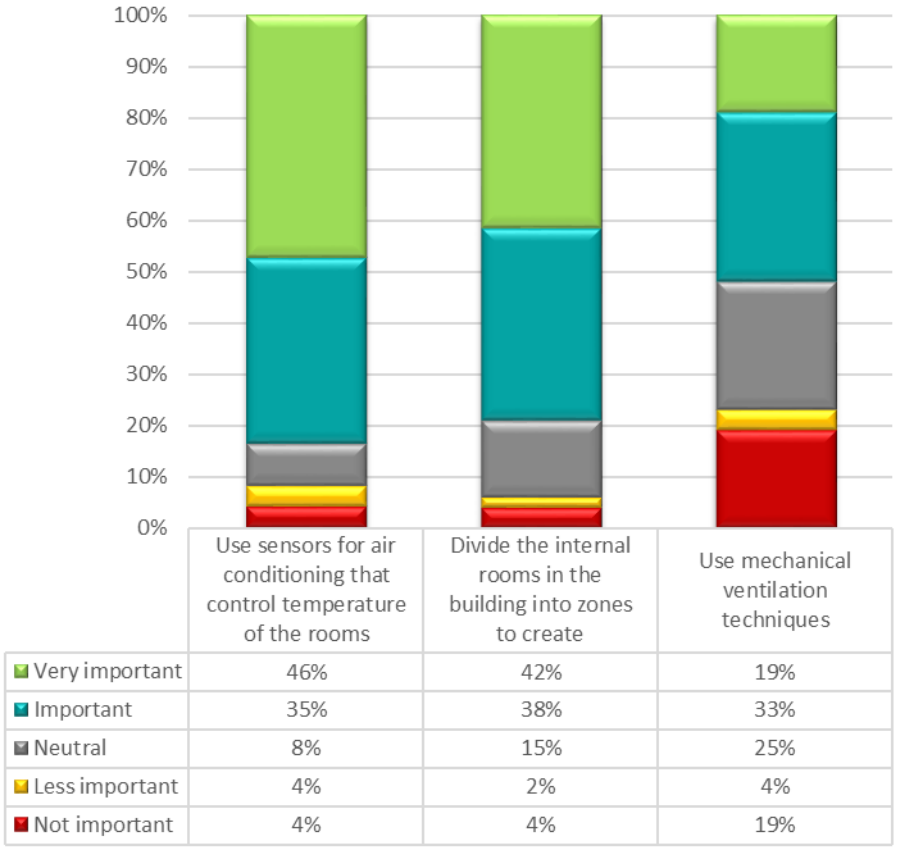


Figure 6.12: *HVAC strategies and techniques: Percentages given by experts*

Table 6.16 and Figure 6.12, when the experts were enquired about the HVAC strategies 80% (38/48) of participants indicated that it is very important (42%, 20/48) and important (38%, 18/48) to separate the rooms within the home to make smaller more efficient ones. While a significant 86% (39/48) indicated that it is very important (46%, 22/48) and important (35%, 17/48) of the respondent's sample opted to make use of a sensory system that will keep the environment in the room comfortable in relation to heat or coolness. While only 52% (25/48) of the population thinks that mechanical ventilation is very important (19%, 9/48) and important (33%, 16/48). Hence, the survey response reflects that the use of the sensors is considered to be.

In order to recover energy, it would make sense if the rooms are separated and each room had its own cooling or heating unit. The panel in round 1 mentioned that the best way to handle the system is by having buttons that will control the climate within each building to make it a comfortable one. This is however something that the public do not use or consider within their homes. Due to the lack of public knowledge in relation to saving and protecting energy, these ideas are not being used within buildings to make living better (chapter 5).

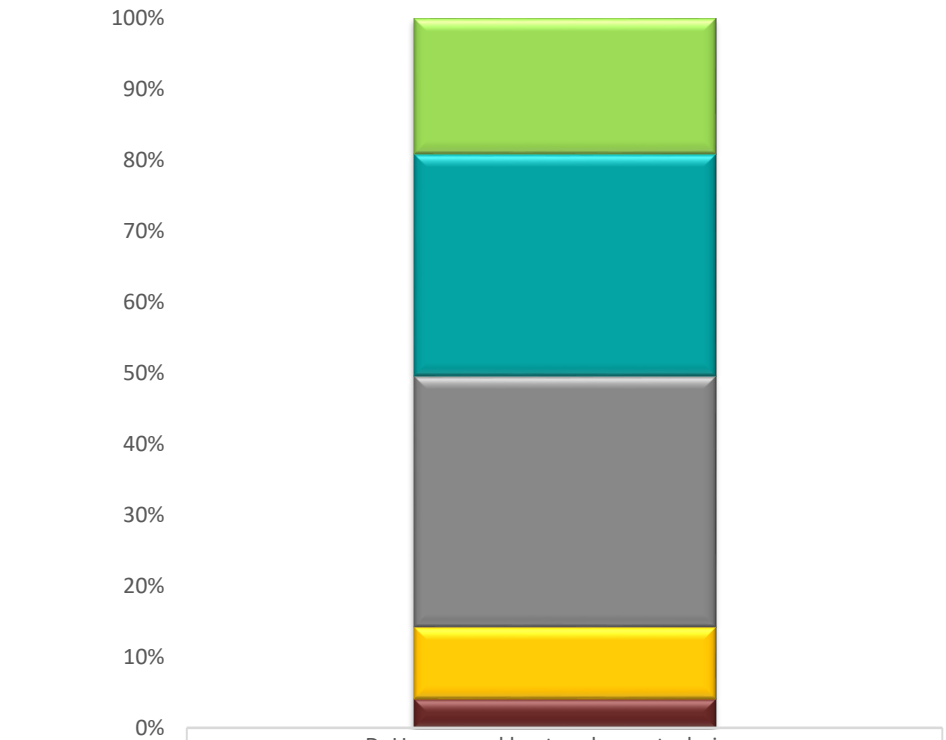
Participants had suggested further options for exploration in the topic of "shading device":

D: Use ground heat exchange techniques

These aspects were ranked by the experts as for the previous batch. The rankings are presented in Table 6.17 and Figure 6.13.

Table 6.17: *HVAC techniques and strategies: Suggestions for further techniques by the experts*

HVAC		Total	%	Mean	IQR
D: Use ground heat exchange techniques	Not important	2	4%	**3.5**	**1**
	Less important	5	10%		
	Neutral	17	35%		
	Important	15	31%		
	Very important	9	19%		



	D: Use ground heat exchange techniques
Very important	19%
Important	31%
Neutral	35%
Less important	10%
Not important	4%

Figure 6.13: *HVAC techniques and strategies: Suggestions for further techniques by the experts*

It is notable that 50% (24/48) of the respondents thinks that it is very important (19%, 9/48) and important (31%, 15/48) to use ground heat exchange techniques to confirm the importance of air conditioning units and to minimise the use of energy, while 4% (2/48) of the respondents have perception that it is not important.

- **Natural ventilation:**

Using the same ranking approach as described previously, all respondents (48) had been asked the following question:

Q.14	**Natural ventilation:** Look at the list below of ways of improving ventilation in order to					
		1. Not important	**2. Less important**	**3. Neutral**	**4. Important**	**5. Very important**
	A:the use of windows for ventilation of the building					
	B: build air shafts by the use of ventilation methods					
	C: have an open plan inside to provide good					
	D:Have 2 windows in each room to create good air flow					
	E:Use efficient court yard design to provide natural ventilation inside and outside the house					

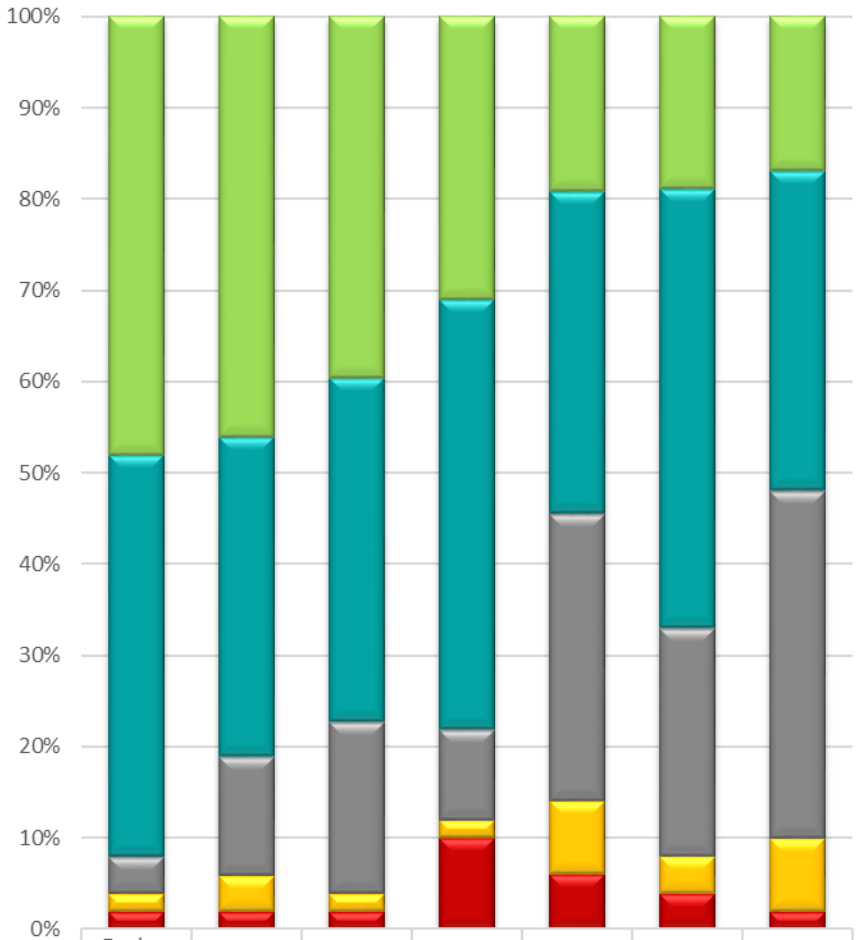
While working on the structure of the building it is quintessential to also consider the natural ventilation process. Natural ventilation helps to control the air circulation throughout the building without making use of any mechanical devices such as air-conditioning systems. It is also known as the passive cooling, and it takes gain of pressure differences as well as the air movement to maintain the temperature comfort inside the living spaces (Awbi, 2002).

Natural ventilation is one of the most important solutions in Iraq, Baghdad. However, if you travel to the Northern parts where is it not as hot, there is a choice. Using natural airing means that it will work alongside the HVAC system in scorching temperatures and in the cooler weather it can be the choice of the individual of its use. Table 6.18 and Figure 6.14 show that experts support natural ventilation and have stated that the location of the building, having a large courtyard and having larger spaces inside the home will all play a vital role in creating natural airing. The inner of the building is usually designed with

what the customer wants, although by using larger, open spaces this can still promote natural airing around the home.

Table 6.18 : *Natural ventilation strategy and techniques: Percentages given by experts*

Natural ventilation		Total	%	Mean	IQR
A: Use windows to ventilate the building	Not important	3	6%	**3.27**	**1**
	Less important	4	8%		
	Neutral	15	31%		
	Important	17	35%		
	Very important	9	19%		
B: build air shafts by the use of ventilation methods	Not important	1	2%	**3.56**	**1**
	Less important	4	8%		
	Neutral	18	38%		
	Important	17	35%		
	Very important	8	17%		
C: design the indoor by suitable plan in order to provide interior airflow	Not important	2	4%	**3.71**	**1**
	Less important	2	4%		
	Neutral	12	25%		
	Important	23	48%		
	Very important	9	19%		
D: more windows for natural lighting and air	Not important	5	10%	**3.98**	**1**
	Less important	1	2%		
	Neutral	5	10%		
	Important	22	47%		
	Very important	15	31%		
E: have larger spaces in doors to support good air flow	Not important	1	2%	**4.35**	**1**
	Less important	1	2%		
	Neutral	2	4%		
	Important	21	44%		
	Very important	23	48%		
F: Face the building towards the North side which will create better air and prevent heat from the sun	Not important	1	2%	**4.16**	**1**
	Less important	1	2%		
	Neutral	9	19%		
	Important	18	38%		
	Very important	19	40%		
G: Use efficient courtyard design to provide natural ventilation inside and outside the house	Not important	1	2%	**4.20**	**1**
	Less important	2	4%		
	Neutral	6	13%		
	Important	17	35%		
	Very important	22	46%		



	Design the building so as to have space inside which will support the natural ventilation	Use efficient courtyard design to provide natural ventilation inside and outside the house	Orientate the building to the north to provide ventilation and avoid solar heat	Place windows in the wall in order to have natural light and air stock	Use windows to ventilate the building	Design the indoor by suitable plan in order to provide interior airflow.	B: Use ventilation tower technique to create air shafts/stacks
Very important	48%	46%	40%	31%	19%	19%	17%
Important	44%	35%	38%	47%	35%	48%	35%
Neutral	4%	13%	19%	10%	31%	25%	38%
Less important	2%	4%	2%	2%	8%	4%	8%
Not important	2%	2%	2%	10%	6%	4%	2%

Figure 6.14: *Natural ventilation strategy and techniques: Percentages given by experts*

Table 6.18 and Figure 6.14 show a large proportion (54%, 26/48) of those questioned agree that windows can be used for ventilation purpose, while 6 %(3/48) of the population size disagrees to this fact.

It is also notable that 52% (25/48) of the respondents thinks that it is important (35%, 17/48) and very important (17%, 8/48) to use the ventilation tower technique, while 67% (32/48) of the respondents have perception that it is very important (48%, 23/48) and important (19%, 9/48) to design the indoors of the building such that it provides for maximum interior airflow.

It is also notable that 78% (38/48) of the respondents for the use of windows to have natural light and air stock. While 92% (44/48) of the respondents thinks that it is very important (48%, 23/48) and very important (44%, 21/48) to design a building optimally to have a natural ventilation within.

Moreover, 78% (37/48) of the respondents indicates that it is significant to face the front of the building to the northern side to get the best circulating of air and also to prevent getting heat from the sun. Consequently, 81% (39/48) of the respondents believes that it is efficient to use the courtyard design for natural ventilation inside and outside the building.

To be conclusive, majority of the respondents is favour of installing the windows for natural ventilation, while the second-best option that is agreed upon by the majority respondents is to orientate the building to north for lesser heat and controlled natural ventilation.

Architects can take these ideas and methods with regards to better natural ventilation into account when they start designing further homes, see Table 6.18 and Figure 6.14.

Participants hadn't suggested any further options for exploration in the topic of "natural ventilation".

- **Analysis of building envelope design techniques and methods**

Using the same ranking approach as described previously, all respondents (48) had been asked the following question:

	Look at the list below in relation to the best way in covering a building to minimise energy demand					
		1. Not important	**2. less important**	**3. Neutral**	**4. Important**	**5. Very important**
Q15	**A:**house thickness covering (wall, roof, and floor)					
	B:Conductivity of materials					
	C:Resistance of the materials					
	D:Type of Insulation materials					
	E: Utilise thick covering through up dated construction equipment that can be purchased on home soil					
	F: Utilise the correct materials in order to keep coolness in the building					

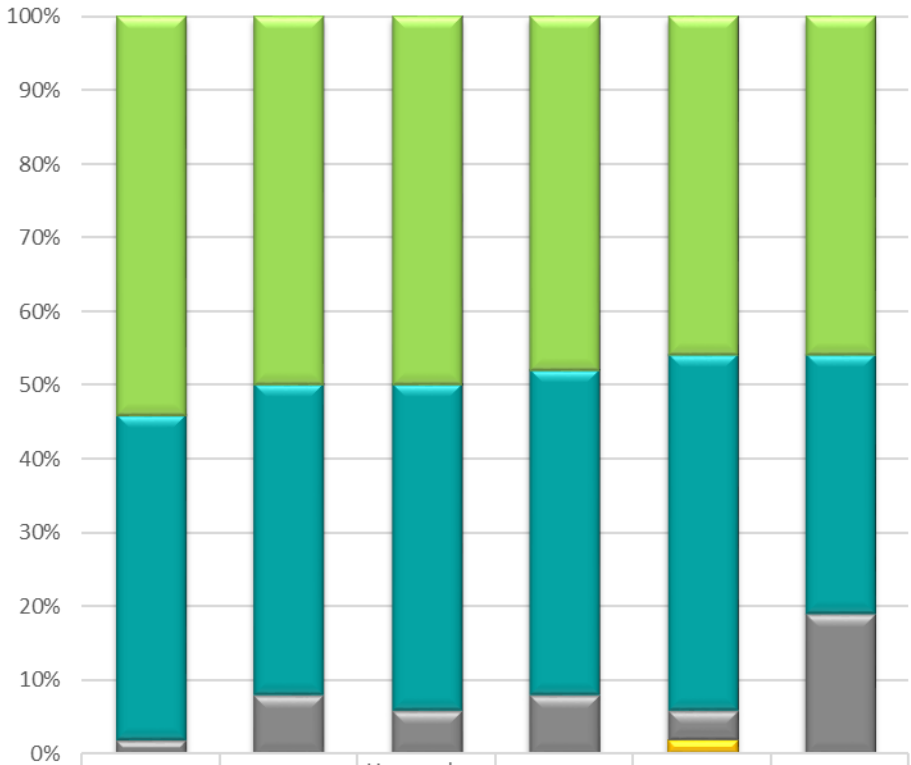
This question asks to explore expert's opinions on the most efficient energy reduction ideas and methods in relation to, 'how to cover the building effectively' can be adapted based on their experience. This question would help in clarifying the main factors that can affect houses in the future.

The building envelope refers to the entire outside of the building that helps to keep coolness, dryness or a warmness environment inside, while also facilitating controlling the temperature of the climate. It is one of the specialized areas of architectural and engineering practice that needs through perusal (Sadineni, et al., 2011).

The professionals have examined the envelope design strategies for hot climates where the covering of the buildings relate to the outside walls and glazing as well at the roof and the floors. Table 6.19 and Figure 6.15 show some methods that need to take place when producing the designs (all given a rating of more than 4 out of 5).

Table 6.19 : *Building strategies and techniques: Percentages given by experts*

Building envelope		Total	%	Mean	IQR
A:Thickness of the house envelop(wall, roof, and floor)	Not important	0%	0%	**4.27**	**1**
	Less important	0	0%		
	Neutral	9	19%		
	Important	17	35%		
	Very important	22	46%		
B:Conductivity of materials	Not important	0	0%	**4.395**	**1**
	Less important	0	0%		
	Neutral	4	8%		
	Important	21	44%		
	Very important	23	48%		
C:Resistance of the materials	Not important	0	0%	**4.416**	**1**
	Less important	0	0%		
	Neutral	4	8%		
	Important	20	42%		
	Very important	24	50%		
D:Type of Insulation materials	Not important	0	0%	**4.52**	**1**
	Less important	0	0%		
	Neutral	1	2%		
	Important	21	44%		
	Very important	26	54%		
E: Utilise thick covering through up dated construction equipment that can be purchased on home soil	Not important	0	0%	**4.437**	**1**
	Less important	0	0%		
	Neutral	3	6%		
	Important	21	44%		
	Very important	24	50%		
F:Using relevant materials to keep coolness	Not important	0	0%	**4.40**	**1**
	Less important	1	2%		
	Neutral	2	4%		
	Important	23	48%		
	Very important	22	46%		



	Type of Insulation materials	Resistance of the materials	Use modern construction materials which have high insulation and are available in the country	Conductivity of materials	Use a suitable construction material in terms of coolness retention	Thickness of the house envelop(wall, roof, and floor)
Very important	54%	50%	50%	48%	46%	46%
Important	44%	42%	44%	44%	48%	35%
Neutral	2%	8%	6%	8%	4%	19%
Less important	0%	0%	0%	0%	2%	0%
Not important	0%	0%	0%	0%	0%	0%

Figure 6.15: *Building envelope strategies as well as techniques: Percentages given by experts*

Table 6.19 and Figure 6.15 show that a large proportion of the people questioned think that the thickness of the building envelope is one of the major aspect to be considered. Moreover, 92% (44/48) (48%, 23/48 very important and 44%, 21/48 important) of the respondents indicates that the conductivity of the materials is also need to be considered in the design plan, along with the material's resistance as agreed by the 92% (44/48) (50%, 24/48 very important and 42%, 20/48 important) of the respondents.

In addition, 98% (47/48) (54%, 26/48 very important and 44%, 21/48 important) of the participants responded that it is extremely important to consider the types of insulating materials as well. The 50% (24/48) of the survey response indicated that it is very important to use modern construction materials, having high insulation, while 46% (22/48) responded that it is also very important to make use of the relevant construction material to maintain comfort temperature.

Hence, as indicated in the survey it is essential to consider the factors of material conductivity, resistance as well as the type of insulating material in relation to the envelope of the building.

From the results, one can see that the professionals were of the same opinion that it is vital to have good building protection from the outside in order to prevent the inside getting too hot, as well as good insulation. An example of this is, using material that has low conductivity, this is because the thicker the material, the more likely it is to reduce the U-value of the building outside.

Participants hadn't suggested any further options for exploration in the topic of "building envelope".

- **External walls design**:

Using the same ranking approach as described previously, all respondents (48) had been asked the following question:

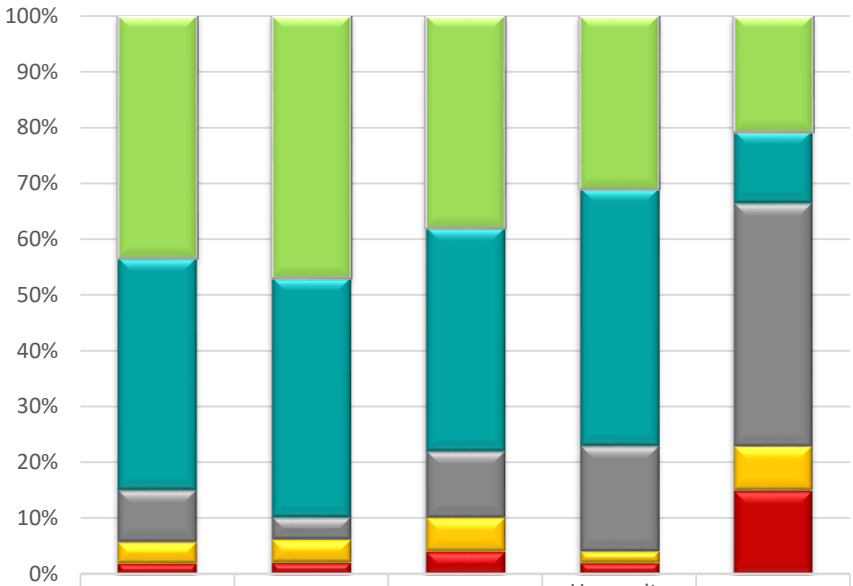
	There are many different materials that can be used on the walls outside in order to reduce energy. Examine the below options:					
Q.17		**1. Not important**	**2. less important**	**3. Neutral**	**4. Important**	**5. Very important**
	A: Usage of wall materials with good insulation properties.					
	B:Design external walls with solid clay brick					
	C: protecting the outside walls with mud so that they are insulated well					
	D build double walls for the outside					
	E: Usage of cavity methods on the outside walls (they will act as air ducts for heat-exchange reasons).					

The external wall designs need a thorough consideration by an architect. This is due to the fact that the exterior walls of a house have several functions. Not only it defines the shape of a building, but it also supports the floors, walls, and the roofs (Chalermyanont & Benson, 2005).

Successful implementation of the walls outside of the building is vital in very warm countries and involves a lot of thought in relation to materials and ideas. Table and Figure 7.18 shows the ways in which the outside walls of the building can be designed so to minimise energy.

Table 6.20 : *Exterior wall strategies and techniques: Percentages given by experts*

External Wall		Total	%	Mean	IQR
A: Use wall materials with good insulation properties.	Not important	1	2%	**4.31**	**1**
	Less important	2	4%		
	Neutral	2	4%		
	Important	20	42%		
	Very important	22	46%		
B: Design external walls with solid clay brick	Not important	2	4%	**4.0**	**1**
	Less important	3	6%		
	Neutral	6	12%		
	Important	19	40%		
	Very important	18	38%		
C: protecting the outside walls with mud so that they are insulated well	Not important	7	15%	**3.29**	
	Less important	4	8%		
	Neutral	21	44%		
	Important	6	13%		
	Very important	10	21%		
D: build double walls for the outside	Not important	1	2%	**4.33**	**1**
	Less important	2	4%		
	Neutral	5	10%		
	Important	21	44%		
	Very important	22	46%		
E: Use cavity techniques in external walls (they will act as air ducts for heat-exchange reasons).	Not important	1	2%	**4.21**	**1**
	Less important	1	2%		
	Neutral	9	19%		
	Important	22	46%		
	Very important	15	31%		



	Use double skin walls in designing the external walls	Use wall materials with good insulation properties.	Design external walls with solid clay brick	Use cavity techniques in external walls (Incorporate walls with cavities that act as air ducts for heat-exchange purposes).	Design external walls with Mud in order to be highly insulated
Very important	46%	46%	38%	31%	21%
Important	44%	42%	40%	46%	13%
Neutral	10%	4%	12%	19%	44%
Less important	4%	4%	6%	2%	8%
Not important	2%	2%	4%	2%	15%

Figure 6.16 : *Exterior Wall strategies and techniques: Percentages given by experts*

Table 6.20 and Figure 6.16 show that 88% (42/48) (42%, 20/48 important and 46%, 22/48 very important) of the sample participants thinks that a good insulating material must be used for the walls, while 2% (1/48) reflects that it is not of importance. While comparing between the wall designs using solid clay brick and mud, majority (78%, 27/48) reflects that using mud is much more important for the exterior wall designs.

However, the 80% (43/48) of the participants responded that it is very important (46%, 22/48) and important (44%, 21/48) to make use of double skin walls, but 2% (1/48) responded that it is not important. In addition, 65% (31/48) indicated that it is also very

important (31%, 15/48) and important (46%, 22/48) to use cavity techniques for external wall design that act as air ducts for heat-exchange purposes, but 2% (1/48) does not think that it is important.

There are many ways in which the external walls can be designed in Iraq, Baghdad. The results from the survey reveal that the respondents agreed that all of the ideas and methods were considered relevant (rated above 3).

Hence, comparing the results it is notable that majority of the respondents for the use of cavity techniques. Having double layers on the wall is also vital when preparing homes in Iraq, Baghdad.

Participants hadn't suggested any further options for exploration in the topic of "external wall".

- **External glazing**

Using the same ranking approach as described previously, all respondents (48) had been asked the following question:

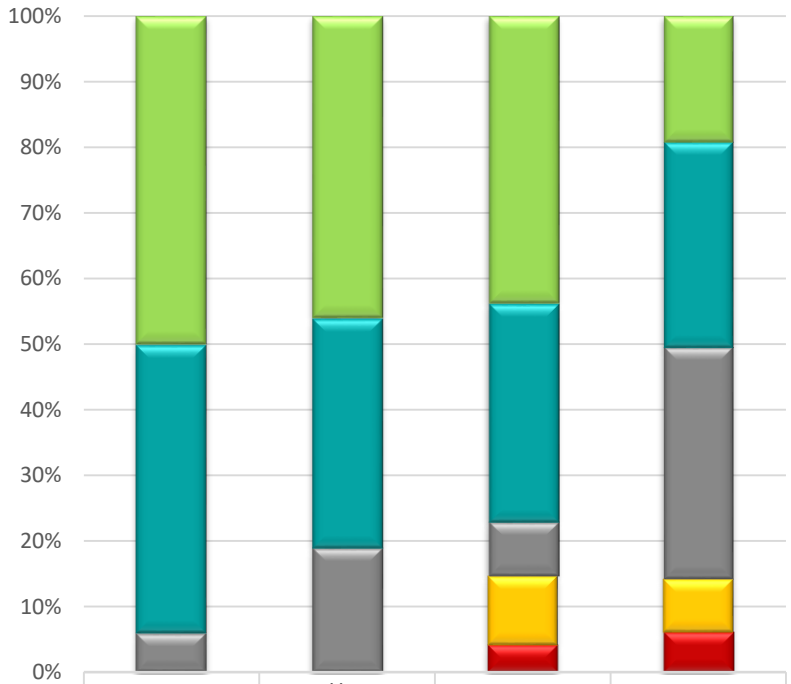
Q.18	There are a number of ways to use glazing. Look at the options below and decide which minimise the demand for energy					
		Not important	**Less important**	**Neutral**	**Important**	**Very important**
	A: Increase thickness glazing					
	B: Use double/ triple glazing and have air pockets between them					
	C: Use double/triple glazing and have argon gas between panels					
	D: Use highly air tight windows					

It is important to get the external glazing correct as this saves' energy inside the homes. If successfully implemented, they can also reduce solar heat and in turn minimise the use of energy. Glazing is the weak point in a building's overall thermal performance and a major source of heat loss.

Table 6.21 and Figure 6.17 show four different ways of implementing glazing in Iraq that are highly effective.

Table 6.21 : *External glazing strategies and techniques: Percentages given by experts*

External glazing		Total	%	Mean	IQR
A: the glazing would need to have more thickness	Not important	2	4%	**4.0**	**1**
	Less important	5	10%		
	Neutral	4	8%		
	Important	17	32%		
	Very important	20	42%		
B: Use double/triple glazing and have air enclosed in the panels	Not important	0	0%	**4.27**	**1**
	Less important	0	0%		
	Neutral	9	19%		
	Important	17	35%		
	Very important	22	46%		
C: Use highly air tight windows	Not important	0	0%	**4.437**	**1**
	Less important	0	0%		
	Neutral	3	6%		
	Important	21	44%		
	Very important	24	50%		
D: Plaster could be used for insulating glaze on the outside windows	Not important	3	6%	**3.47**	**1**
	Less important	4	8%		
	Neutral	17	35%		
	Important	15	31%		
	Very important	9	19%		



	Use highly air tight windows	Use double/triple glazing and have air enclosed in the panels	The glazing would need to have more thickness	Plaster could be used for insulating glaze on the outside windows
Very important	50%	46%	42%	19%
Important	44%	35%	32%	31%
Neutral	6%	19%	8%	35%
Less important	0%	0%	10%	8%
Not important	0%	0%	4%	6%

Figure 6.17: *External glazing strategies as well as techniques: Percentages given by experts*

Table 6.21 and Figure 6.17 show that 74% (41/48) (32%, 17/48 important and 42%, 20/48 very important) of the sample participants think that increasing the thickness of glass must be used because this will play an important part in rising the efficiency of the glaze, while, 4% (2/48) reflects that it is not of importance. However, the 81% (39/48) of the participants responded that it is very important (46%, 22/48) and important (35%, 17/48) to use a number of glazing units (double/triple) and have air pockets in the middle of them to increase the efficiency of buildings in the country. In addition, 94% (45/48) indicated that it is also very important (50%, 24/48) and important (44%, 21/48) to use highly airtight windows than original frames as a feature of external

glazing design. Using plaster for glaze insulation for external windows is also seen as an important factor.

Participants hadn't suggested any further options for exploration in the topic of "external wall".

- **Efficient Roof and Floor Design**

The utilizing of energy plays an important factor in very warm climates and therefore the design of the roof and grounds of homes need to be constructed well just like the country being analysed here.

Efficient roof design:

Using the same ranking approach as described previously, all respondents (48) had been asked the following question:

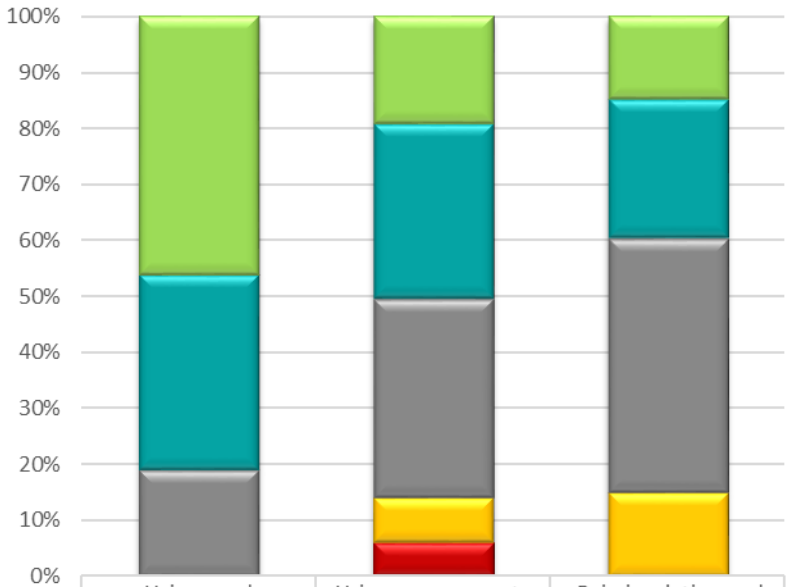
Q.18	Look at the options below and analyse which are important in building a roof that will minimise the use of energy.					
		1. Not important	**2. Less important**	**3. Important**	**4. Important**	**5. Very important**
	A: Rain insulation and wood materials would be used when constructed the outside roof above the concrete.					
	B: Using good insulation materials and concrete when building the roof outside above the concrete					
	C: Using green grass to increase the insulation when building the external roof above the concrete					

A building is basically defined by its roofing design. A perfect external roof provides optimal protection from the environmental hazards such as the rain and can essentially aid in controlling the temperature, thus there is a dire need to consider its design (Erell, 2013).

Table 6.22 and figure 6.18 show the response from the respondents on the possible ideas and methods that could be implemented to build a roof that would overall save energy.

Table 6.22 : *Efficient roof strategies as well as techniques: Percentages given by experts*

Efficient roofing design		**Total**	%	**Mean**	**IQR**
A: Rain insulation and wood materials would be used when constructed the outside roof above the concrete.	Not important	0	0%	**3.39**	**1**
	Less important	7	15%		
	Neutral	22	46%		
	Important	12	25%		
	Very important	7	15%		
B: Using good insulation materials and concrete when building the roof outside above the concrete	Not important	0	0%	**4.27**	**1**
	Least important	0	0%		
	Neutral	9	19%		
	Important	17	35%		
	Very important	22	46%		
C: Using green grass to increase the insulation when building the external roof above the concrete	Not important	3	6%	**3.47**	**1**
	Least important	4	8%		
	Neutral	17	35%		
	Important	15	31%		
	Very important	9	19%		



	Using good insulation materials and concrete when building the roof outside above the concrete	Using green grass to increase the insulation when building the external roof above the concrete	Rain insulation and wood materials would be used when constructed the outside roof above the concrete.
Very important	46%	19%	15%
Important	35%	31%	25%
Neutral	19%	35%	46%
Less important	0%	8%	15%
Not important	0%	6%	0%

Figure 6.18 : *Efficient roof strategies as well as techniques: Percentages given by experts*

Table 6.22 and Figure 6.18 show that only 40% (19/48) (25%, 12/48 important and 15%, 7/48 very important) of the sample participants reflects that the external roof must be designed raised over the concrete construction consisting of rain insulation and materials made from wood. While, 81% (39/48) of the participants thinks that it is very important (46%, 22/48) and important (35%, 17/48) to ensure that the roofs outside the building which are above the concrete are built with insulation materials and tiles made of concrete. Moreover, 50% (24/48) (19%, 9/48 very important and 31%,15/48 important) thinks that the external roof must be designed to have green grass in order to increase the insulation, while 6% (3/48) indicates that it is not that important. Hence, it is notable that the majority of the participant's size opts for efficient insulation materials and concrete tiles to build the exterior concrete roof of the building.

Participants had suggested further options for exploration in the topic of "efficient roofing design":

D: A gap can be made above the structure which could stop direct heat coming in at night. This would be due to efficient ventilation.

These aspects were ranked by the experts as for the previous batch. The rankings are presented in Table 6.23 and Figure 6.19.

Table 6.23 : *Efficient roofing techniques and strategies: Suggestions for further techniques by the experts*

Efficient roofing design		Total	%	Mean	IQR
D: A gap can be made above the structure which could stop direct heat coming in at night. This would be due to efficient ventilation.	Not important	3	6%	3.47	1
	Less important	4	9%		
	Neutral	17	35%		
	Important	15	31%		
	Very important	9	19%		

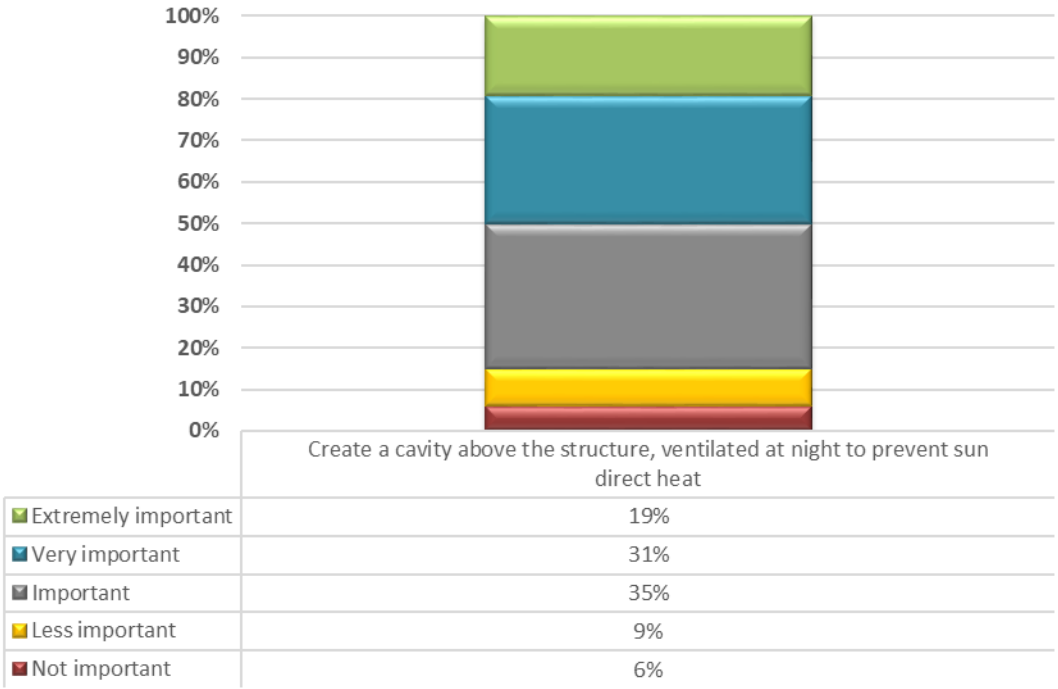


Figure 6.19 : *Efficient roofing techniques and strategies: Suggestions for further techniques by the experts*

Table 6.23 and Figure 6.19 show that 50% (24/48) (19%, 9/48 important and 31%, 15/48 very important) of the participants thinks that using the technique of building a gap over the structure must be used as important factor which can stop the sun from entering the home at night if it is ventilated correctly. While, 6% (3/48) reflects that it is not of importance.

- **Efficient floor design:**

Using the same ranking approach as described previously, all respondents (48) had been asked the following question:

Q.19	IV. Efficient floor design: Please look at the option below in relation to materials that could be used when building the roof. These methods reduce the usage of energy.	Not important	Less important	Neutral	Important	Very important
	Usage of mud insulation, mortar and concrete tiles					
	Use wood insulation materials					
	Using a massive layer of sand and tiles made of concrete					

Along with the roof techniques and strategies, it is also essential to consider the design of the floor as it not only beautifies the exterior of the building but it also provides a superficial covering to the ground of the building eliminating the bumps and curves (Thrush, 2006).

Table 6.24 and Figure 6.20 show the experts' ratings (round 1) of possible ideas and methods in relation to building the floor to achieve an efficient, energy saving floor design.

Table 6.24 : *Efficient floor strategies as well as techniques: Expert's average rating*

Efficient floor design		Total	%	Mean	IQR
A: Use natural materials such as marble or stone tiles	Not important	2	4%	**4.0**	**1**
	Less important	3	6%		
	Neutral	6	12%		
	Important	19	40%		
	Very important	18	38%		
B: Usage of mud insulation mortar also using tiles made from concrete	Not important	2	4%	**3.96**	**1**
	Less important	2	4%		
	Neutral	11	23%		
	Important	14	29%		
	Very important	19	40%		
C: Use wood insulation materials	Not important	7	15%	**3.04**	**1**
	Less important	4	8%		
	Neutral	21	44%		
	Important	10	21%		
	Very important	6	13%		

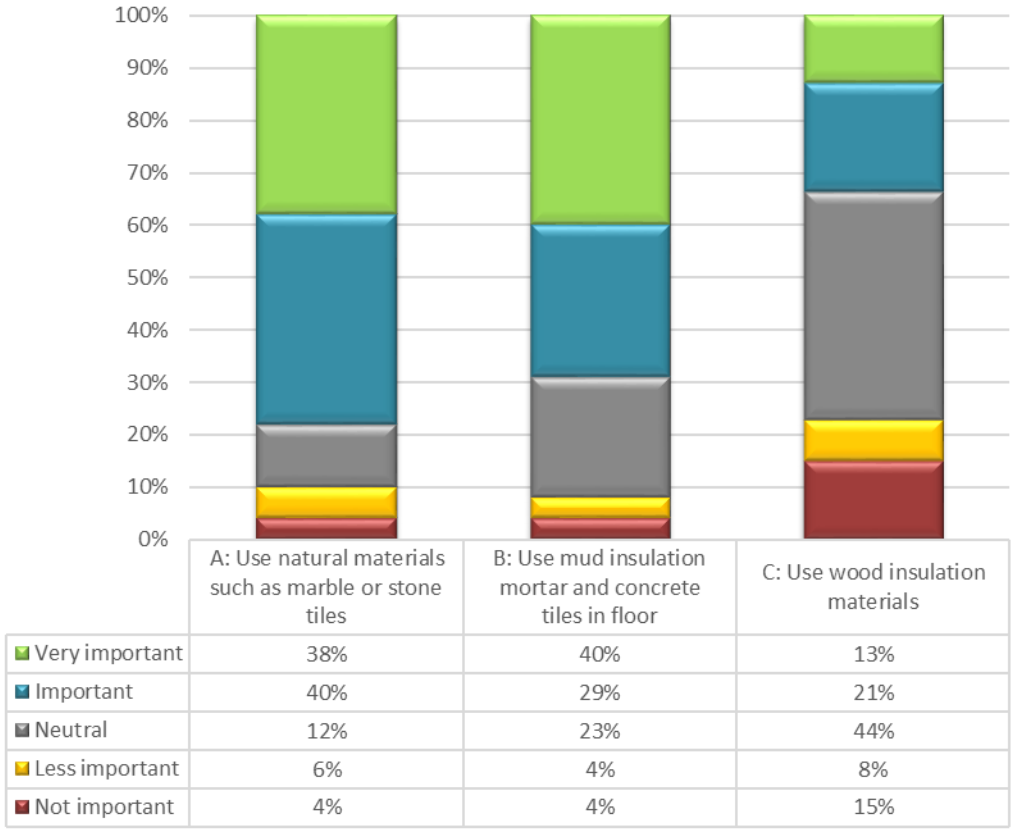


Figure 6.20 : *Efficient floor strategies as well as techniques: Expert's average rating*

Table 6.24 and Figure 6.20 show that 78% (37/48) (38%, 18/48 important and 40%, 19/48 very important) of the participants thinks that the use of natural materials such as marble or stone tiles is best for outside floor, while 4% (2/48) indicates that it is not that important. While 69% (33/48) of the participants reflect that it is very important (40%, 19/48) and important (29%, 14/48) to utilise mud insulation mortar and have tiles on the floor made from concrete. Moreover, only 33%(16/48) indicates that it is very important (13%, 6/48) and important (21%, 10/48) to use wood insulation materials, though 15% (7/48) negates its importance.

Participants had suggested further options for exploration in the topic of "efficient roofing design":

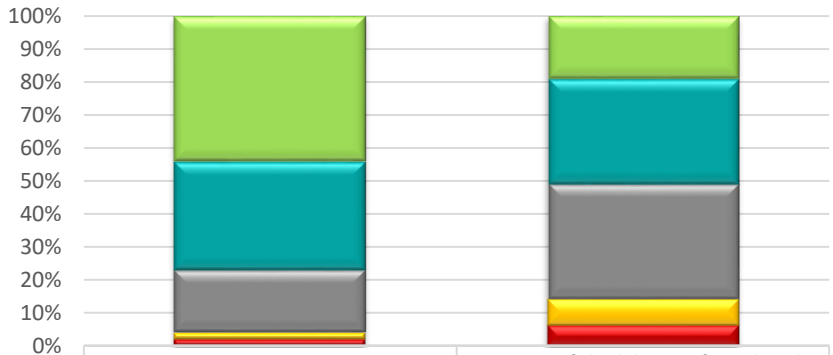
D: Usage of thick layer of sand and have the tiles on the floor made from concrete.

E: Use natural stone in floors

These aspects were ranked by the experts as for the previous batch. The rankings are presented in Table 6.25 and Figure 6.21.

Table 6.25 : *Efficient floor techniques and strategies: : Suggestions for further techniques by the experts*

Efficient floor design		Total	%	Mean	IQR
D: Usage of thick layer of sand and have the tiles on the floor made from concrete.	Not important	3	6%	**3.47**	**1**
	Less important	4	8%		
	Neutral	17	35%		
	Important	15	32%		
	Very important	9	19%		
E: Use natural stone in floors	Not important	1	2%	**4.14**	**1**
	Less important	1	2%		
	Neutral	9	19%		
	Important	16	33%		
	Very important	21	44%		



	Use natural stone in floors	Usage of thick layer of sand and have the tiles on the floor made from concrete.
Very important	44%	19%
Important	33%	32%
Neutral	19%	35%
Less important	2%	8%
Not important	2%	6%

Figure 6.21 : *Efficient floor techniques and strategies: Suggestions for further techniques by the experts*

Table 6.25 and Figure 6.21 show that 51% (24/48) of the participants indicates that it is very important (19%, 9/48) and important (32%, 15/48) to use a thick sand layer and have the tiles made of concrete on the exterior floor. However, 77% (37/48) of the population reflects that it is very important (44%, 21/48) and very important (33%, 16/48) to use natural stone in floors. Thus, the survey indicates that the majority of the population were of the opinion of using natural stones as a good method of minimizing the consumption of energy, as it is readily available in the country.

The results show that in the first and second rounds, the experts had agreed to a range of the strategies and techniques discussed in relation to building these kinds of homes for the country. They rated the vital element was the usage of good materials for insulating above the concrete roof construction on the roof outside. Experts suggested using the idea of having a gap over the structure which could work as a ventilator in the evening and prevent sun from entering the home. With regards to insulating the floor, most of the experts agreed that the usage of natural stones as one of the best ways to minimise consuming energy. As a bonus, this is a resource that 'one can get his hands on' easily in the country. In addition, the usage of sand with a thick layer and tiles made of concrete are also a notable idea.

6.2.4 Part E: Perception of cultural barriers to the delivery of low energy houses

The way of living in a country plays an important role when designing a building and this goes for Iraq too. Therefore, minimizing energy techniques need to change to suit this way of living.

Using the same ranking approach as described previously, all respondents (48) had been asked the following question:

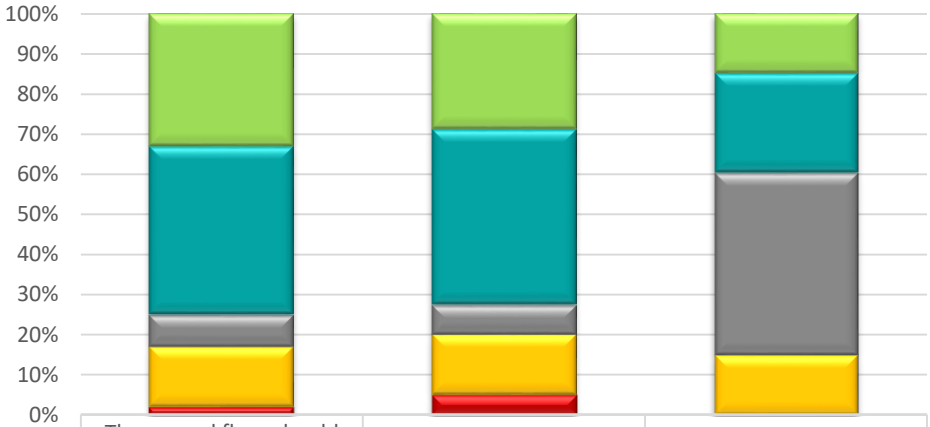
All respondents (48) were asked the following question:

Q.21	**Social- cultural aspects** Look at the options below and analyse them in terms of saving energy based on the amount a room is used					
		Not important	**Less important**	**Neutral**	**Important**	**Very important**
	A: make the rooms that are used the most; smaller, such as bedrooms					
	B: the ground floor should be used for rooms that are used the most (bedrooms) whilst the second floor should be used for rooms that are used the least, such as the guest room					
	C: the underground story should be used the most as it is the coolest compared to the ground level					

Table 6.26 and Figure 6.22 show how, according to the experts the different design ideas to save energy whilst still maintaining people's general cultural way of living in the city.

Table 6.26: *Social- cultural image strategies as well as techniques: Experts' average rating*

Social- cultural *image*		**Total**	**%**	**Mean**	**IQR**
A: make the rooms that are used the most; smaller, such as bedrooms.	Not important	2	4%	**3.65**	**1**
	Less important	6	12%		
	Neutral	3	6%		
	Important	17	35%		
	Very important	11	23%		
B: the ground floor should be used for rooms that are used the most (bedrooms) whilst the second floor should be used for rooms that are used the least, such as the guest room.	Not important	1	2%	**3.89**	**1**
	Less important	7	15%		
	Neutral	4	8%		
	Important	20	42%		
	Very important	16	33%		
C: the underground story should be used the most as it is the coolest compared to the ground level.	Not important	0	0%	**3.39**	**1**
	Less important	7	15%		
	Neutral	22	46%		
	Important	12	25%		
	Very important	7	15%		



	The ground floor should be used for rooms that are used the most (bedrooms) whilst the second floor should be used for rooms that are used the least, such as the guest room	Make the rooms that are used the most; smaller, such as bedrooms	The underground story should be used the most as it is the coolest compared to the ground level
Very important	33%	23%	15%
Important	42%	35%	25%
Neutral	8%	6%	46%
Less important	15%	12%	15%
Not important	2%	4%	0%

Figure 6.22: *Social- cultural image strategies as well as techniques: Experts' average rating*

Table 6.26 and Figure 6.22 show that 58% (38/48) of the sample participants were given a percentage either important (35%, 17/48), or very important (23%, 11/48) to create smaller rooms that are used the most, such as bedrooms. However, 75% (36/48) of the participants thinks that it is either important (44%, 21/48), or very important (33%, 16/48) to moving the rooms around the building to minimise the consumption of energy, such as having the bedrooms on the group floor as opposed to upstairs. Moreover, 40% (19/48) of the sample participants were given a percentage either important (25%, 12/48), or very important (15%, 7%) for using the underground story as opposed to the first floor.

Participants had suggested further options for exploration in the topic of "social-cultural image":

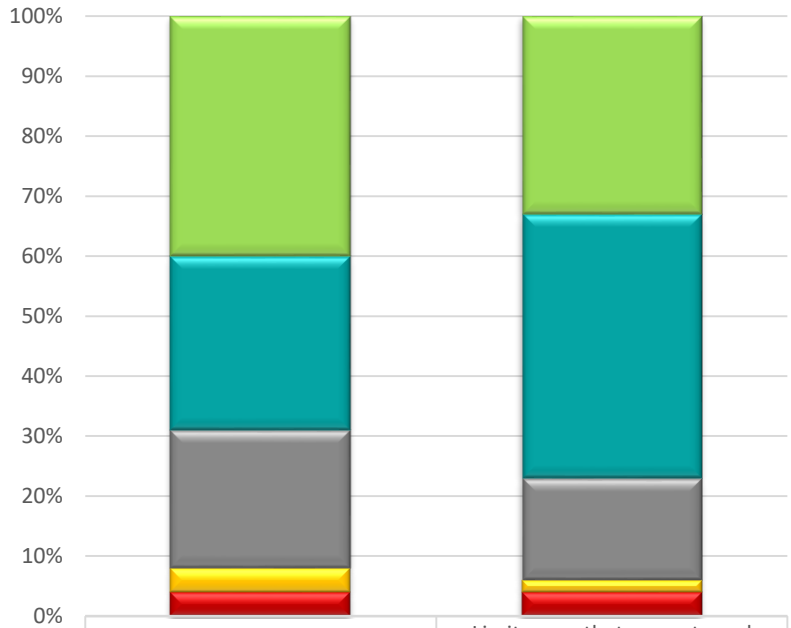
D: Limit areas that are not used and add no benefit to the building;

E: Using the roof terrace for sleeping and different activities.

These aspects were ranked by the experts as for the previous batch. The rankings are presented in Table 6.27 and Figure 6.23.

Table 6.27 : *Social- cultural image techniques and strategies: Suggestions for further techniques by the experts*

Social- cultural image		Total	%	Mean	IQR
D: Limit areas that are not used and add no benefit to the building	Not important	2	4%	**4.0**	**1**
	Less important	1	2%		
	Neutral	8	17%		
	Important	21	44%		
	Very important	16	33%		
E: Using the roof terrace for sleeping and different activities	Not important	2	4%	**3.96**	**1**
	Less important	2	4%		
	Neutral	11	23%		
	Important	14	29%		
	Very important	19	40%		



	Using the roof terrace for sleeping and different activities	Limit areas that are not used and add no benefit to the building
Very important	40%	33%
Important	29%	44%
Neutral	23%	17%
Less important	4%	2%
Not important	4%	4%

Figure 6.23 : *Social- cultural image techniques and strategies: Suggestions for further techniques by the experts*

Table 6.27 and Figure 6.23 show that that 77% (37/48) of the sample participants were given a percentage either important (44%, 21/48), or very important (33%, 16/48) to get rid of the areas in the building that are not used at all. While 2% (1/48) of participants indicates that, it is less important. Also, 69% (33/48) of the sample participants were given a percentage either important (29%, 14/48), or very important (40%, 19/48) to use the roof terrace for sleeping and different activities. On other hand, 4%(2/48) of participants indicate that, it is less important.

Experts suggest that getting rid of idle rooms is vital and most important if one does not want to waste energy. An example being guest rooms that may only be used on a monthly basis. Another suggestion is to make the bedrooms smaller in size because these are the

type of rooms that utilise a considerable amount of energy because they are unnecessarily too large for what they are used for. Another way of trying to limit using less energy is to move the rooms around the home, such as putting the larger rooms that use the most energy on the ground floor (i.e. the insulation is a result of the top floor) and other rooms, for instance, the guest rooms as well as the kitchen on the first floor (as they use less energy). Therefore, this can lead to the entire home playing a part in minimizing the consumption of energy.

Also, 69% (33/48) of experts suggest that the roof terrace could be used as a sleeping area overnight during the summer and for different activities. On the other hand, 4% (2/48) of respondents indicate that it is not important of using the roof as a sleeping area during the summer and explained this was because the wall was not high enough to prevent overlooking. Such a roof terrace could satisfy the inhabitant's needs and provide them with complete privacy if the parapet wall was high enough to prevent overlooking by neighbours.

6.3 Key Findings

The interviews for experts offered rich in-depth perceptions as well as understandings of the many problems that surround the move towards modernity and away from vernacular in Iraqi's, Baghdadi's, houses. It also added to discussions for the prospective of usage of vernacular elements in today's houses. Below the most significant findings:

- The use of courtyards was recognized as the best traditional vernacular component based on consultations. When asked about issues facing the contemporary house, the most participants specifically identified the lack of a courtyard. Moreover, in question 5, the participants recognized the courtyard as the key traditional vernacular element they used in house design. This reinforces how people directly relate the courtyard to the vernacular courtyard house.
- When asked question five, i.e. in contemporary houses, should vernacular elements be used, 85% (41/48) of experts said yes. However, when asked question 7, if there are vernacular elements currently in their house 42% (20/48) of experts said no. The question then arises, if people desire the applications of these elements why are they not used in their current houses? The findings revealed contradictions in participants' responses, which suggests disconnects in understandings between vernacular and contemporary. Conversely, when asked question four, the purpose of this question is to expose issues facing contemporary homes in Baghdad which can be addressed using vernacular features. The text responses were categorized into the four categories: socio cultural; environmental sustainability; commercial\ government's role; and spatial issues.
    - In describing the problems that facing contemporary house applicants mainly discussed socio-cultural aspects. The houses were described as being "hospitable", designs of adjacent houses served to build, and strengthen social fabrics through families and neighbourhood's bonds. Its simple design provided people's needs and maintained socio-cultural norms and privacies. In compare when describing the contemporary houses participants generally expressed a negative tone referring to the new houses as being "unfriendly". Although heavily discussed by experts, when asked if vernacular features should be applied in contemporary

house, and the reason for their answer (Q.5), culture was ranked first by experts (31%, 15/48) and followed by environmental sustainability (27%, 14/48). However, in question 6, when participants were asked to rank the importance of factors in designing their house, culture ranked the third (19%, 9/48) behind the environmental sustainability (35%, 17/48) and identity (31%, 15/48). Participants do perceive traditional vernacular components as expressions of environmental sustainability as well as cultural importance. However, it is then questionable as to why these participants do not recognize the significances for their dwelling designs. This can mean that while residents value and recognize their cultural identities, they may not prioritise or express their views in the built environments.

- In order to capture the understanding of participants on the issue of environmental sustainability, several questions were included on this topic in the questionnaire. Vernacular houses were perceived to be more environmentally sustainable by the participants. Moreover, the next question (3) enquired regarding the significant factors in their houses. 35% (17/48) chose the most significant factor as environmental sustainability. Identities, cultures as well as modernism were the other following factors.
- Nevertheless, upon further investigation of participants regarding the applicability of vernacular components in their homes, cultural factor was ranked the first highest (31%, 15/48) and environmentally sustainable design was ranked the second lowest (27%, 14/48). This was a strange finding as the participants identified the environmental sustainability to be the most significant factor for their homes, however, they did not state that this factor will have a great significance in the design of their upcoming homes. Furthermore, based on the responses of question 5, 85% of participants (41/48) stated that traditional vernacular components must be applied in contemporary homes. This was justified by socio-cultural factors as well as environmental sustainability.
- Environmental sustainability was found to be a key factor in relation to designing homes. Yet, inconsistencies in the responses provided by participants show that while environmental sustainability is acknowledged as an important factor, it is not

considered to be the main factor for application in traditional vernacular elements as the experts chose social culture as the first choice.

- An important finding was that of spatial issues. This is a representation of the participants' views on the current and past domestic architectures. The use of space as well as spatial aspects for modernization have been recognized as the most significant features in present-day Baghdad houses. Furthermore, 100% (48/48) of experts believed there were issues with current homes where cultural aspects as well as spatial features were ranked most in the responses (40%, 19/48). Waste of space was reflected by spatial problems. Participants described their homes as huge mixed "box like" and "multi-storey concrete structures" with poor space utilization and large rooms. Perhaps, the responses provided by the participants highlight the reality of economic as well as socio-cultural factors. To elaborate, residents are continuously adjusting to the clash between modern practices as well as vernacular concepts.
- Using vernacular elements was supported by experts who confirmed it to be a positive solution for environmental problems affecting the built environment. It was suggested that these environmental problems should be tackled by government initiatives as well as through house designs. Several cultural understandings were given priority as well.
- The experts have, in general, negatively discussed about the government's role along with its lack of the role. Promoting better qualities in built houses in Baghdad is important according to the experts. Also, some participants mentioned that Mayoralty of Baghdad must take into consideration the changing needs of people of Baghdad along with the proposal of building codes as well as new regulations. In addition, the individuals left with responsibility for implementing the building codes are trying to adapt to current needs by allowing exceptions to the building codes. However, such independent adaptation to the situation can cause its own issues. To elaborate, a disconnection appears between the built environment and existing laws as well as design realities in Baghdad. While governmental bodies were blamed solely by some experts, these experts did not propose any suggestions for reform. Nevertheless, some experts recognised the issues along with recommending various possible ideas for implementation for improving existing domestic built environment designs. It appears that experts didn't have optimistic outlooks.

- Moving to a more detailed analysis of building elements to reduce energy consumption and facilitate use of renewable energy, the key findings are listed below.
- The respondents indicated that the orientation and the spacing of a building is critical to the evaluation of architectural designs. The orientation can consequently affect large number of factors needed to be taken care of (eg window and shading position).
- Window provide openings for natural ventilation and is also opted as the best and efficient HVAC system by the sample population.
- Good building envelope designs is essential. A good design will have resistance to the harsh weather and should balance the building's interior immaculately. Consequently, the external roof must be designed to provide proper insulation within the building. While the external floor design must be opted to beautify the exterior of the building using the natural stones.
- Rooms with greater sizes such as bedrooms must be reduced in size in order to make homes more energy efficient. Moreover, according to experts, spaces with no significance for the buildings must be reduced.

6.4 Summary

This study has taken experts opinions and views into account in relation to sustainable homes in Baghdad. The study has found issues that lead to consuming a lot of energy as well as how people live their everyday lives having a huge effect on developing sustainable homes. Each factor was discussed in turn with possible alternative strategies to reduce the consumption of energy and minimizing CO2 emission rates.

This study also highlighted cultural issues influenced the development of successful sustainable homes. Ideas were therefore discussed to prevent these barriers and the advantages socially, economically and environmentally were highlighted and how these points could be implemented when constructing these homes.

It is important to take experts views on board in relation to the building of homes in the past and present. This is because it gives an understanding of the challenges the country faces in creating a modern Baghdad but it also gives the opportunity to look at how to build sustainable constructions in the future.

Tables from 6.10 to 6.27 illustrate the IQR for each of the 70 individual criterion. The results from Tables 6.10 to 6.27 show that 63 of the criterion achieved a mean ranking of 3.5 to 5, thus showing their importance. The 63 supported criterion are presented in Table 6.28 with their associated mean ranking and IQR. These appear to be applicable to Baghdad's current and upcoming weather conditions along with taking into consideration the city's cultural requirements and the availability of local raw materials. Based on the experts' suggestions, each design technique shown in Table 6.28 was confirmed to be suitable for the culture, environment as well as climate of Baghdad. Following on, this can assist in establishing design frameworks for sustainable houses in the city of Baghdad, which can be used for supporting decision-makers, civil engineers, architects and developers relating to the several construction industries in the city for designing energy efficient homes.

Table 6.28: *The rank of responses attained for the strategies as well as design techniques recognised by experts' consultations.*

				Tools all mean from 3.5-5	***Mean***	***IQR***
Strategies categories	***Architectural Design***	Massing and space layout	1	Taking the buildings surroundings into account	4.416	1
			2	Building structure considering the direction of the wind	4.33	1
			3	Shading device	4.08	1
			4	Internal subdivisions	4.08	1
			5	The architectural shape of the property	4.06	1
			6	Usage of terraced or semi-detached houses	4.02	1
			7	Orientation of the building (south-north facing)	4.02	1
			8	Minimizing building size as possible	4.02	1
			9	Using Green buildings techniques	3.96	1
			10	Sloped-shape for minimising the sun exposure	3.86	1
			11	Increase green area around the building	3.5	1
		Window's Design	1	Reduce windows area	4.27	1
			2	Use color glaze for external windows	4.208	1
			3	Decrease the number of windows	4.16	1
			4	Growth of greenery	3.625	1
			5	Shelter the windows by the use of canopies	3.56	1
		Shading device	1	Have shading umbrellas on the outer windows	3.08	1
			2	Use effective courtyard landscape designs for providing shading effects to the building	4.16	1
			3	Use sun louver techniques.	3.85	1
			4	Using nature such as large trees to protect the home and provide protection from the sun	3.79	1
			5	Creating shading effect with horizontal canopies	3.5	1
			6	Shading of Ventilated Façade	4.06	1
			7	Use sun reflection design techniques	3.458	1
			8	use covers on the inside and outer windows to stop sun from going inside the building	3.95	1
			9	Use roof shading techniques	4.59	1
		HVAC	1	use sensors that will keep the rooms at a comfortable degree by the use of the air conditioner	4.16	1
			2	Have smaller rooms so that the heating/cooling systems are only used when in that room. Therefore energy is not wasted.	4.08	1
			3	Usage of mechanical ventilation approaches	3.96	1
			4	Usage of ground heat-exchange approaches	3.5	1
		Natural ventilation	1	have larger spaces in doors to support good air flow	4.35	1
			2	Use efficient courtyard design to encourage natural ventilation inside and outside the house	4.20	1
			3	Face the building towards the North side which will create better air and prevent heat from the sun	4.16	1
			4	More windows from natural lighting and air	3.98	1
			5	Design the indoor by suitable plans for providing internal airflows	3.71	1
			6	Build air shafts by the use of ventilation methods	3.56	1
	House envelope design	Building envelope	1	Type of Insulation materials	4.52	1
			2	Utilise thick covering through up dated construction equipment that can be purchased on home soil	4.437	1
			3	Material shortage	4.416	1
			4	Utilise the correct materials in order to keep coolness in the building	4.40	1
			5	Potential of the materials	4.395	1
			6	Thickness of the house envelop(wall, roof, and floor)	4.27	1
		External Walls	1	build double walls for the outside	4.33	1
			2	Use wall materials with good insulation properties.	4.31	1
			3	Usage of cavity methods on the outside walls (they will act as air ducts for heat-exchange reasons)	4.21	1
			4	Using solid clay brick for designing exterior walls	4.0	1
		External Roof	1	Using good insulation materials and concrete when building the roof outside above the concrete	4.27	1
			2	A gap can be made above the structure which could stop direct heat coming in at night. This would be due to efficient ventilation	3.48	1
			3	Using green grass to increase the insulation when building the exterior roofs	3.47	1
		Floor Design	1	Use natural materials such as marble or stone tiles	4.0	1
			2	Use natural stone in floors	4.14	1
			3	Usage of mud insulation, mortar and concrete tiles	3.96	1
			4	Using a massive layer of sand and tiles made of concrete	3.47	1
		External Glazing	1	Use highly air tight windows	4.437	1
			2	Have more of a layer of thickness for the glazing	4.0	1
			3	Use double/ triple glazing and have air pockets between them	4.27	1
	On-Site renewable energy		1	Use the best PV that is available	4.06	1
			2	Using solar radiation to heat DHW	4.041	1
			3	Use of wind energy	3.81	1
			4	PV could be used on the tops of the eastern and western sides of the building.	3.69	1
			5	PV could be used on the top of the southern side of the building.	3.5	1
	Cultural aspects and image		1	make the rooms that are used the most; smaller, such as bedrooms	4.19	1
			2	Limit areas that are not used and add no benefit to the building	4.0	1
			3	the ground floor should be used for rooms that are used the most (bedrooms) whilst the second floor should be used for rooms that are used the least, such as the guest room	3.89	1

Chapter 7

Discussion Design Strategies for Future House in Baghdad

Chapter 7

7.1 Introduction

This chapter provides a synthesis of the results achieved from the literature review (chapter 2); bioclimatic analysis (chapter 4); public perception survey (chapter 5); and experts' perception survey (chapter 6) to inform the progress of the appropriate design strategies for new housing units in Baghdad. It is anticipated that this will require a combination of contemporary technology with passive design fundamentals to provide occupant comfort while reducing energy consumption compared to contemporary Baghdadi housing. Using such an approach will assist in responding to the final research objective:

> ***Objective 7:*** *Propose a framework for design strategies for new housing units in Baghdad, that appropriately combines contemporary technology with passive design fundamentals in order to provide comfortable and energy efficient housing solutions that are able to satisfy householder's functional expectations as well as social and cultural expectations and needs.*

To date, the following stages have been achieved by the present research:

Stage one:

- Studying, analysing and identifying feasible passive strategies for application in the Baghdadi climate.

Stage two:

- Examining levels of householders' (public) satisfaction with both contemporary and vernacular houses with regard to their environmental and cultural performance.

Stage three:

- Engaging with professionals and understanding their ideas on designs and construction in terms of passive designs of modern housing units in Baghdad: for example, academics, the government, and the private sector.

This chapter will apply the findings from Chapters Four, Five, and Six, combined with the literature findings, to inform design strategies for new residential units in Baghdad needed for incorporating various modern technologies using passive design procedures to provide enhanced and naturally appealing housing possibilities and solutions that will fulfil social, comfort and functional demands.

In the discussion below, these findings are discussed along with conclusions drawn from the relevant literature. The final outcome will be a consolidation of all the outcomes that helped in concluding this whole research into an informed set of design strategies.

7.2 Design strategies for synthesised house design for Baghdad

To reduce the energy consumed by air conditioning systems and to create energy-efficient buildings, this study offers insights into setting up various design strategies for residential units in Baghdad that are needed to incorporate various modern technologies using passive design procedures to provide enhanced and naturally appealing housing possibilities and solutions that will fulfil social and functional demands.

The three key passive design strategies have been identified as Shading, Natural ventilation, and Evaporative Cooling. These three strategies for the Baghdad city, selected using the bioclimatic design (chapter 4), are taken into consideration in combination with the findings from the literature review (Chapter 2), the public survey (Chapter 5), and the expert survey (Chapter 6) to develop appropriate strategies for this context.

The design strategies for synthesised house designs in Baghdad will now be established. This will be undertaken by synthesising the findings from the literature review, the bioclimatic analysis, the public survey, and the expert survey. The analysis considers the urban fabric factors and architecture design factors as key themes that will be discussed.

Table 7.1 summarizes the design strategy recommendations obtained by each phase to develop appropriate strategies for this context

Table 7.1: *The design strategy recommendations obtained by each theme*

Design strategies			**Passive design strategies The direct impact**
Urban fabric aspects	Compactness and street layout	Compactness	Self-shade from solar gains and Natural ventilation
		Walkability	Shading
		Wider street/ Car access	Natural ventilation
	Orientation		Natural ventilation and Heat gain
	Outside zone	Courtyard	Shading, Natural ventilation, Heat gain and Evaporative cooling
		Plant and water features	
Architecture design aspects	Form		Shading, Natural ventilation and Heat gain
	Window design	Size of window	Shading and Natural ventilation
		Shading device	
	Glazing design		Heat gain
	Envelope design		Heat gain
	Roof terrace design		Sun shading and Natural ventilation
* winter season strategies e.g. heat gain			

In Baghdad, the severe environmental conditions differ through the year due to hot summers and cold winters: hence, the optimal design strategies should be able to respond to such changes. The results presented here for developing design strategies concentrate on the summer season; although some factors are also appropriate to heat gain in winter, the summer season is highly challenging, as the essential requirement is cooling.

7.2.1 Urban fabric factors

Urban fabric aspects represent a series of considerations, which were described in previous chapters. These are taken into consideration in order to develop the design strategies.

Urban fabric factors	Compactness and street layout
	Orientation
	Outside zone

7.2.1.1 Compactness and street layout

***Literature review*:** It has been found from the literature revealed that the urban fabric of the vernacular areas is compact. This facilitates socialising and walking to workplaces, schools and shops; however, it now causes difficulties for car access due to the alleyways, which are mostly narrow. Conversely, in contemporary areas, the urban fabric has wide streets, with better ventilation potential and easy access for cars, but the benefit of shading is lost.

***Bioclimatic analysis view*:** It was found that the most efficient passive strategies for the whole year for Baghdad are sun shading, natural ventilation, and evaporative cooling. With careful consideration, the compact urban fabric as achieved by Baghdad's vernacular design strategies can support natural ventilation as well as self-shading. Moreover, a more compact design exposes a lower proportion of the building fabric to solar radiation.

Public survey views: The urban form of a city is formed according to the sociocultural effects and as an appropriate response to climatic regions with the experience of centuries. Though we cannot claim that they are the only reasons for the formation of layouts, the effects of both sociocultural and climatic regions of Iraq should not be neglected. However, knowledge of urban fabric factors and the approaches to their application are not widespread. This highlights the need to inform people on the importance of urban design because of the important characteristics of house design, especially in terms of

wind and solar radiation. Governments must work in regulating the markets and promoting the need to adopt specific design strategies, which should be taken into account when building future houses.

Expert survey views: The respondents believed that passive design strategies should be a key factor in the construction of contemporary houses, but knowledge of these strategies and their methods of application are not widespread. This has highlighted the need to inform and educate designers and engineers about the importance of using urban design to reduce the amount of building areas exposed to solar radiation.

Adoption in Design Strategies

Theme	Factor	Literature Review	Bioclimatic Analysis	Public Survey	Expert Survey	Adopt in Design Strategies?
Urban Fabric	Compactness and street layout	Y	Y	-	-	Y

Guidance for Adoption of Design Strategy: During the planning and construction of new homes, the distance between the houses and other places must be taken into consideration.

Table 7.2. a and b show the recommended design strategies for future house design in Baghdad, Iraq.

Table 7.2.a: *The design strategies recommendations for Urban fabric\Compactness and street layout*

<table>
<tr><td>Design Strategy:</td><td>Urban fabric</td><td colspan="4">Compactness and street layout</td></tr>
<tr><td rowspan="3">Drivers:</td><td>Market:</td><td colspan="4">Vernacular house\ Contemporary house</td></tr>
<tr><td>Passive:</td><td colspan="4">Self-shade from solar gains +Natural ventilation</td></tr>
<tr><td>Social:</td><td colspan="4">Enhance social relationship</td></tr>
<tr><td>Objectives:</td><td colspan="5">• To provide self-shade from solar gains and ventilation.
• To reduce damage to the current environment and enhanced walkability as well as sharing spaces and services.
• To reduce the paved areas of the site and thus reduce the gain.
• To enhance sociocultural interactions between neighbors.</td></tr>
<tr><td rowspan="2">Urban fabric design vernacular and contemporary situation:</td><td colspan="2" rowspan="2">Vernacular layout
• Provide shading
• Walkability \satisfy the needs of pedestrians.
• Natural ventilation
Contemporary layout
• Completely neglected the needs of pedestrians.
• No shading\street width and inappropriate design has prevented buildings from being effective in casting shade to protect the streets.
• Car access.
• Natural ventilation</td><td>Vernacular layout: The width of the alleys is no more than 1.5m-3m while the proportion of the alleys to the building height is almost 1:10. This helps to shade almost the entire facades and alleys. Also, attach the building to reduce the exposed surfaces.

Pedestrian streets
Courtyards
Source:Aalhashem,2008</td><td>
Source: Researcher</td><td>Contemporary layout: The straight and parallel streets open the city to wind ventilation. The grid patterns and wider streets increase the radiation in its straight streets. Lack of appropriate covers and trees and vegetation in straight streets causes severe heat (in hot-dry climate) wind blow into the streets due to straight air movement.

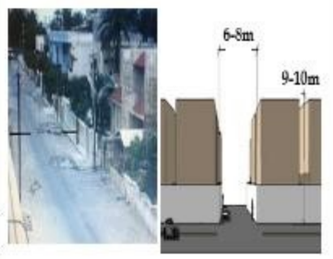
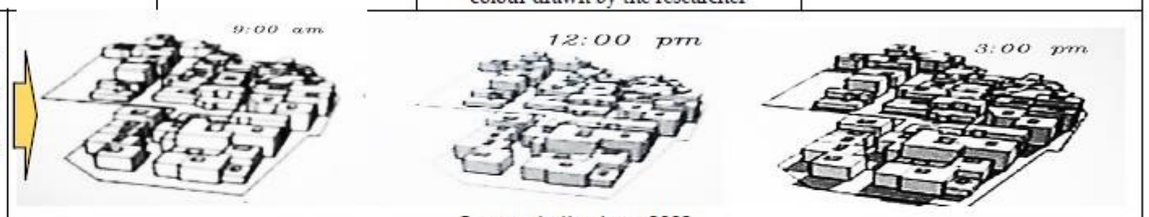
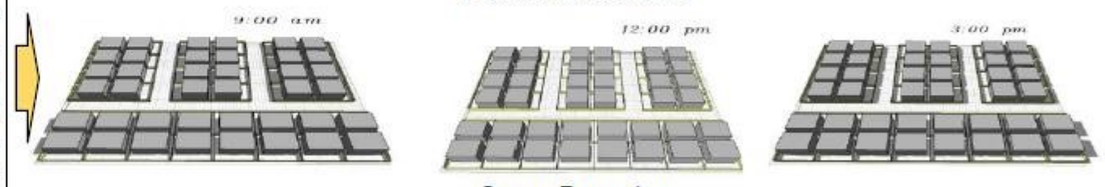
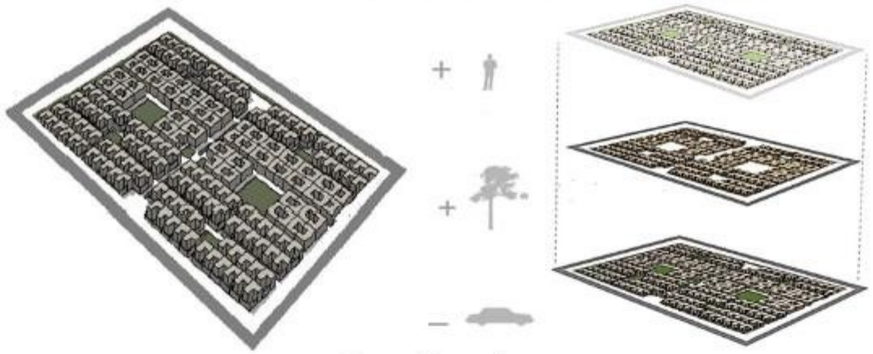
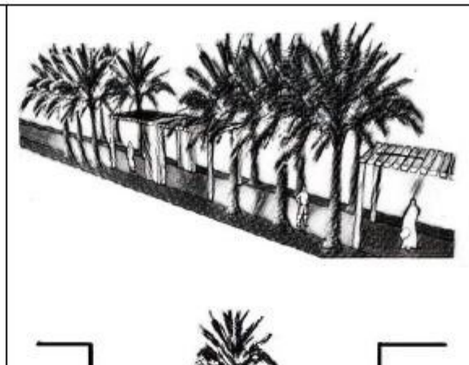
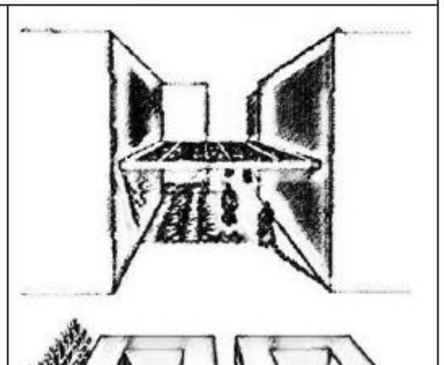
Main street\ vehicle streets
Motor-vehicle streets not used by pedestrians
Source: Google maps (2019)\The yellow colour drawn by the researcher</td><td>
Source: Researcher</td></tr>
<tr><td colspan="5">Vernacular layout: The effect of the street design in Baghdad on providing shadows in the alleys. Shadows in the alleys on June 21st. Streets are receiving enough shade at the critical time of the day. Notice that the configuration has effect on creating an effective shade.

Source:Aalhashem,2008
Contemporary layout: The effect of the street design in Baghdad on providing shadows in the street. Shadows in the streets on June 21st. Streets are not receiving enough shade at the critical time of the day. Notice the east- west-east oriented street gets no shade at all throughout the day. Notice also that even the shadows created are the result of the sun position. The configuration has no effect on creating an effective shade.

Source: Researcher</td></tr>
</table>

Table 7.2.b: *The design strategies recommendations for Urban fabric\Compactness and street layout*

<table>
<tr><td>Design Strategy:</td><td>Urban fabric</td><td colspan="3">Compactness and street layout</td></tr>
<tr><td rowspan="3">Drivers:</td><td>Market:</td><td colspan="3">Vernacular house\ Contemporary house</td></tr>
<tr><td>Passive:</td><td colspan="3">Self-shade from solar gains +Natural ventilation</td></tr>
<tr><td>Social:</td><td colspan="3">Enhance social relationship</td></tr>
<tr><td>Discussion</td><td colspan="4">A careful review of the vernacular layout shows that the narrow streets promote the wind speed circulation passes through them that helps the wind to reach deeper parts of narrow alleys. The alleys run from the N or NW axis and extend to the S or SW at the leeward side. This design helps the passage of the adequate N and NW winds inside the alleys. The width of the alleys beside the proportion of the alleys to the building height together helps to shade most of the alleys and entire facades. Additionally, the close grouping of buildings provides a small area of surface exposed to solar radiation. The two factors act to promote the wind circulation that helps maintain the required climatic comfort.
On another hand, the contemporary layout with the wide, straight, and parallel streets opens the city to wind ventilation and so better airflow in the layout. The grid patterns increase the radiation in its straight streets. Thus, the layout and street designing in a way that brings the appropriate airflow and utilizes solar access are crucial and vital. This could affect the global climate and energy consumption of buildings. Hence, the study suggests the application of an adequate mixture of both the vernacular and contemporary layout in the design strategies in terms of the urban designs for synthesised house designs for Baghdad.</td></tr>
<tr><td>Design strategy implementation example</td><td colspan="2">
Source: Researcher
This figure shows the strategy outlined in this thesis for retrofitting the current urban layout in Baghdad by improving the climatic and sociocultural responses.
• Increase walkability, reduce vehicles, and increase green area
• Narrow streets - to provide effective shade and air movement during the hot summer.
• Attached residential units to provide shaded outdoor spaces
• The attached forms + narrow pedestrian streets =created shaded neighborhoods spaces \ encourage walkability.
• Open spaces\green area surrounds the unites to create a cooling effect and to filter sandy winds coming from the northern and western direction. Also, to create cool social-gathering outdoor space for inhabitants unites.</td><td>
Source: Researcher
In streets, combination of shading features and local palm trees should be implemented to create cast shading and so providing the cooling effect. Also, encourage walkability and social interaction.</td><td>
Source: Researcher
• Trees and shading elements should provide when required to cast shade.
• Adding trees on the side of building in order to protect the western façade and also to create shaded footpaths.</td></tr>
<tr><td>Implementation Needs</td><td colspan="4">• Professional training will be required for experts to adopt this strategy appropriately.</td></tr>
<tr><td></td><td colspan="4">• The market may require informing of the benefits of compact cities to them and the need to reduce dependence on cars. Public transportation may be provided to enable inhabitants to travel from one to another area, and so to reduce reliance on cars.</td></tr>
<tr><td></td><td colspan="4">• Building laws should be modified, changed and include strict rules that architects, designers and users should follow.</td></tr>
</table>

7.2.1.2 Orientation

Literature review: It was found from the literature review that the orientation of vernacular houses was formed according to sociocultural effects and as an appropriate response to the local climatic regions with the experience of centuries. Though we cannot claim that these are the only reasons for the formation of dwellings, the effects of both sociocultural and climatic responses should not be neglected. For example, in vernacular houses, it is considered very valuable to build the main facade towards "qibla", the direction of the holy land of Islam (Mecca). The optimum orientation for unilateral houses in Baghdad is south, or up to 30° west of south. The direction of Mecca from Iraq is almost south, 20° and 10° west of south. It is evident that these directions are in the optimum range.

However, the orientation of the contemporary houses was not formed according to socio-culture effects or climatic regions. There is no consideration of orientation in designing the houses to face towards "qibla". Moreover, the street layout in contemporary areas based on grid layout results in a high percentage of the rooms being poorly oriented. In many cases, the highly inhabited spaces are located in the wrong orientation for passive solar control.

Bioclimatic analysis view: It was found that the most efficient passive strategies for the whole year for Baghdad are sun shading, natural ventilation, and evaporative cooling. With careful consideration, the orientation of a building, as achieved by Baghdad's vernacular design strategies, can support natural ventilation as well as self-shading.

Public survey views: The orientation of buildings was formed according to the sociocultural effects and as an appropriate response to climatic regions, with the experience of centuries. However, the knowledge of these factors and the approaches to their application are not widespread. This highlights the need to educate people on the importance of the orientation of buildings, because this is an important characteristic in house design, especially in terms of wind and solar radiation. Governments must work in regulating the markets and promoting the need to adopt specific design strategies, which should be taken into consideration when building future houses.

Expert survey views: The experts agreed that the orientation of the building is an important aspect that needs to be considered. They believed that the building orientation must be directed towards south-north to gain potential solar energy in the heating season.

Based on the experts' survey, the orientation criterion achieved a mean ranking of 4 out of 5, thus demonstrating its importance, as shown below. This appears to be applicable to Baghdad's current and upcoming weather conditions, as well as taking into consideration the city's cultural requirements and the availability of local raw materials.

	Mean
Orientation of the building (south-north facing)	4.02

Adoption in Design Strategies

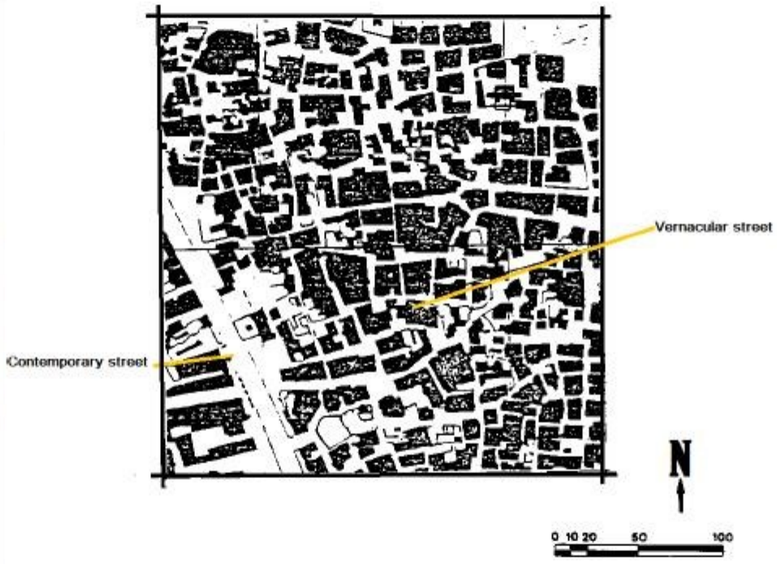
Theme	**Factor**	**Literature Review**	**Bioclimatic Analysis**	**Public Survey**	**Expert Survey**	**Adopt in Design Strategies ?**
Urban Fabric	*Orientation*	Y	Y	-	Y	Y

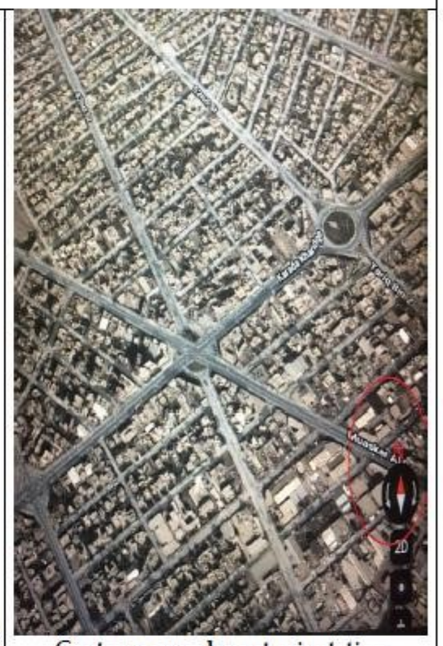
Guidance for Adoption of design strategy: Upon the planning and construction of new homes, the houses orientation must be taken into consideration.

The table 7.3.a and b show the recommended design strategies for future house design in Baghdad.

Table 7.3.a: *The design strategies recommendations for orientation in designing the house*

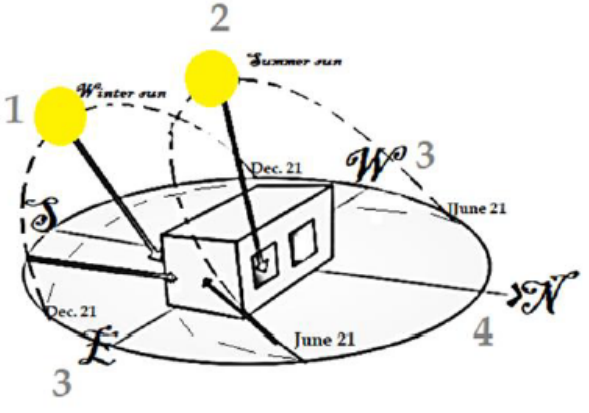
<table>
<tr><td>Design Strategy:</td><td>Urban fabric</td><td colspan="2">Orientation</td></tr>
<tr><td rowspan="3">Drivers:</td><td>Market:</td><td colspan="2">Vernacular</td></tr>
<tr><td>Passive:</td><td colspan="2">Natural ventilation as well as self-shading</td></tr>
<tr><td>Social:</td><td colspan="2">Protection the inner space from the direct gain</td></tr>
<tr><td>Objectives:</td><td colspan="3">• To take advantage of how the sun moves across the sky.
• To avoid of heat gain \ analyze the relation with climate regions, solar angles, and prevailing winds.
• To achieve an effect on the building's thermal performance.</td></tr>
<tr><td>Orientation in vernacular design and contemporary design situation:</td><td colspan="2">Vernacular design
• Consideration to orientation in designing the houses towards "qibla".
• Consideration to solar radiation at different angles and wind direction.
• The street layout in Vernacular areas based on the compact layout and the orientation of the streets have a significant effect on the microclimate around buildings and on the access to sun and wind.

Contemporary design
• No consideration to orientation in designing the houses towards "qibla".
• No consideration to solar radiation at different angles and wind direction.
• The street layout in contemporary areas based on grid layout results in a high percentage of the rooms are poorly oriented. In many houses-The highly inhabited spaces are located in the wrong orientation for passive solar control.</td><td>

A plan shows the comparison in the streets and house layout in vernacular and contemporary design.
In vernacular design, street running North-South and a contemporary street just outside the vernacular city layout.
The street layout of the vernacular area seems to have advantages as regards to the street qualities of lighting and shading. For the period of the summer, shadows are cast all day long into every street running along the North-South axis, except the short period within the midday when the solar altitude is nearly overhead. By comparing with the streets running from the East-West usually receives little shadows between 9:00 am and 3:00 pm, but as the result of the compact design of buildings, the affective street width is very much reduced, leaving the streets in the shadow most of the summer day.
Source: Researcher 2019 depend on Aalhashem(2008)</td><td>
Contemporary layout orientation
Source: *Google maps*

Total surface area, in the contemporary street, on which the sun shines is at least three times that in the vernacular alleys so that there is a greater absorption of solar energy in the contemporary streets.</td></tr>
</table>

Table 7.3.b: *The design strategies recommendations for orientation in designing the house*

<table>
<tr><td>Design Strategy:</td><td>Urban fabric</td><td colspan="3">Orientation</td></tr>
<tr><td rowspan="3">Drivers:</td><td>Market:</td><td colspan="3">-</td></tr>
<tr><td>Passive:</td><td colspan="3">Natural ventilation as well as self-shading</td></tr>
<tr><td>Social:</td><td colspan="3">Protection the inner space from the direct gain</td></tr>
<tr><td>Discussion</td><td colspan="4">So what has been found from the literature review, the bioclimatic analysis, public survey, and the experts survey results is that the urban layout in the vernacular area is totally in harmony with the direction of the prevailing winds, and though the street is oriented for best air flows (N., NW.), adequate pressure differences are created in order to encourage the air movement through all alleys, regardless of orientation. Also, in such a climate, the best orientation of an architectural design plan is north to south (from east to west\ long axis). Due to increased solar penetration arising from the east in the morning and the west in the evening, this orientation is proposed in order to avoid the direct impact of sunlight. Nevertheless, the surrounding environment tends to play a huge role in the building orientation where the former can limit making selections in terms of orientations. Other shading options can be implemented, including vegetation on the west-facing orientation while minimising glazing. The orientations in vernacular urban planning were intended to minimise the solar insolation along with taking advantage of the prevailing wind direction in the buildings. Even with the use of grid layouts, there appear no main reasons for not making use of the same principles in contemporary design and planning. Also, against the vernacular layouts designs, high rises are finding preferences. Though, in view of the advantages of orienting for increasing wind movement as well as reducing isolation in planning would be deemed by architects and designers.</td></tr>
<tr><td>Design strategy implementation example</td><td colspan="2">• Building orientation has an impact on heat gains of the building, through the variety of solar radiation at different angles.
• Building orientation \Long space North-South
• N-S orientation can be used creatively to generate a variety of built and open space.
• Orient the buildings with the long axes in the E-W direction so the longest walls face N and S, and only the short wall face E and W.</td><td>1. In winter, the low sun angle - welcome solar access.
2. In summer, the high sun angle on the south - easy to shade.
3. On East and West- The low sun angle- It is difficult to shade in summer – minimise area.
4. Minimal radiation on the North - allowing large windows for excellent daylight.</td><td>

Source: Researcher</td></tr>
<tr><td rowspan="2">Implementation Needs</td><td colspan="4">• Educate people on the importance of the orientation of building because it is an important characteristic in the house design, especially in terms of the winds and solar radiations.</td></tr>
<tr><td colspan="4">• Building laws should be modified, changed and include strict rules that architects, designers and users should follow. Also, the governments must work in regulating the markets and promoting the need for adopting orientation strategies that should be taken when building the future house.</td></tr>
</table>

7.2.1.3 Outside zone

Literature review: The literature revealed that the concept of courtyards in vernacular houses was formed according to the sociocultural effects and as an appropriate response to bioclimatic regions following centuries of experience. Baghdadi vernacular courtyards are usually planted with flowers, shrubs, and fountains, not only creating a comfortable, pleasant and beautiful gathering space, but also increasing the shading and the relative humidity of the courtyard to provide thermal comfort for their occupants. This creates a comfortable environment for the seasonal usage of the surrounding spaces. The sunny northern side of the courtyard is used during winter, while the shaded southern side is used during summer. Also, the courtyard is important for daylight and ventilation, as well as providing privacy for the inhabitants when undertaking most normal day-to-day activities. Conversely, the contemporary house has a front garden, which is an outside space, rather than a courtyard. The front garden is used for social gatherings with family or neighbours and does not provide any privacy for the occupants. Some contemporary houses have an extension area to the bedroom or living room which is semi-covered with flowers and shrubs. This space does not offer the same characteristics as a courtyard because it does not provide any sense of enclosure. It reflects the characteristics of a modern garden rather than a courtyard. Therefore, contemporary houses do not fulfil the occupants' needs in terms of privacy from neighbours and passers-by.

Bioclimatic analysis view: It was found that the most efficient passive strategies for the whole year for Baghdad are sun shading, natural ventilation, and evaporative cooling. With careful consideration, courtyards, as achieved by Baghdad's vernacular design strategies can support natural ventilation, evaporative cooling, and heat gain, as well as providing the required exposure to the sun, which must be precisely determined. Also, trees or other planting in the courtyard can be used to provide shade and help to cool the environment.

Public survey views: The respondents indicated that strong family ties, as well as social spaces, are highly desirable qualities of courtyards. Based on the results from the survey, it can be confirmed that respondents were aware of the importance of vernacular houses

in providing satisfaction and pleasant indoor thermal comfort. However, the increased real estate costs were seen to be the most important factors preventing the implementation of courtyards, closely followed by small land areas, Iraq's housing crisis, scarcity of residential land, and the absence of governmental regulations to promote courtyards.

Expert survey views: The majority of experts agreed that vernacular architecture had provided very good solutions in the past and had proved its suitability to the climate. They confirmed that if features from vernacular houses were developed and used in a suitable way, this could well help in improving future houses and in providing a special local identity. They also pointed out the importance of convincing people to accept these ideas. Courtyards received the highest percentage choice in the expert's survey, which indicates that experts were likely to apply these conventional vernacular features in their recent or future dwellings. Also, the majority of the respondents believe that it is efficient to use the courtyard design for natural ventilation inside and outside the building.

Adoption in Design Strategies

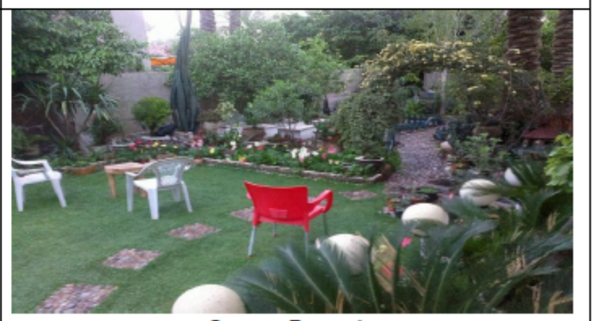
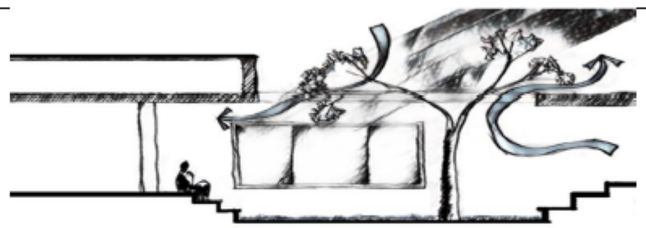
Theme	Factor	Literature Review	Bioclimatic Analysis	Public Survey	Expert Survey	Adopt in Design Strategies?
Sociocultural factors	**Outside zone**	**Y**	**Y**	**Y**	**Y**	**Y**

Guidance for Adoption of design strategy: Upon the planning and construction of new homes, the outside area must be taken into consideration.

The table 7.4 shows the recommended design strategies for future house design in Baghdad.

Table 7.4: *The design strategies recommendations for Urban fabric\outside zone*

<table>
<tr><td>Design Strategy:</td><td>Urban fabric</td><td colspan="2">Outside zone</td></tr>
<tr><td rowspan="3">Drivers:</td><td>Market:</td><td colspan="2">Vernacular house</td></tr>
<tr><td>Passive:</td><td colspan="2">Shading+ Natural ventilation+ Evaporative cooling</td></tr>
<tr><td>Social:</td><td colspan="2">Provide private social gathering space for occupants</td></tr>
<tr><td>Objectives:</td><td colspan="3">• To provides the required natural ventilation between the inside and outside.
• To let sufficient shading through using the correct proportion between the width and height of the courtyard.
• To provide the required humidity for occupant comfort.
• To provide social gathering private space to the house occupants.</td></tr>
<tr><td>Outside zone in vernacular and contemporary house:</td><td>Vernacular courtyard
• Provide natural ventilation, shading, and evaporative cooling.
• Privacy\ social gathering for family.
• Providing the intermediate connection between the various components and sub-units of the house.
Contemporary garden
• No privacy \ social space with family or neighbours
• Views
• Natural ventilation</td><td>Vernacular house\ courtyard as open spaces

Source: Salman,2016</td><td>Contemporary house\Garden as open space

Source: Researcher</td></tr>
<tr><td>Discussion</td><td colspan="3">So what has been found from the literature review, the bioclimatic analysis, public survey, and the experts survey results is that the courtyard from the vernacular house would be useful to be applied in future design because it has the potential to provide privacy for individuals when doing most daily life activities, while the garden in contemporary houses don't provide privacy for individuals especially when it comes to social occasions. Also, the future house can have the front garden with the courtyard to satisfy the socio-cultural needs of the inhabitants.</td></tr>
<tr><td>Design strategy implementation example</td><td>• The courtyard from the vernacular house would be valuable.
• New homes could have frontal gardens with courtyards to satisfy the socio-cultural needs of the inhabitants.
• The concepts of fountain, fine- spray sprinkler, and trees of the vernacular house could be used in the designing strategies of future houses.</td><td colspan="2">
The correct proportion between the width and height of the courtyard would always let to sufficient shading, even during the sun in summer is directly almost overhead. When providing the courtyard with plants and water features, it operates as a cooling source also modifies the climate accordingly.
Source: Researcher

Source: Researcher</td></tr>
<tr><td>Implementation Needs</td><td colspan="3">• Building laws should be modified, changed and include strict rules that architects, designers and users should follow.
• The courtyard design and its features should become compulsory for new buildings in the near future and also should be considered in the building code.
The governments must work in regulating the markets and promoting the need for adopting specific design strategies that should be taken when building the future house.</td></tr>
</table>

7.2.2 Architecture design factors

Architectural design factors represent a series of considerations, as described in previous chapters. These are taken into consideration in order to develop the design strategies.

Architecture design factors	form
	Window design
	Glazing design
	Envelope design
	Roof design

7.2.2.1 Form

Literature review: It has been found from the literature that building shapes have a key role in the overall determination of energy usage in a dwelling. Therefore, an appropriate design for the shape of the building is very important and must be considered at the design stage. In addition, assessing the local weather circumstances is also very important (AlAnzi et al., 2009). To elaborate, building shapes can have an influence on the received solar energy (Mingfang, 2002; Ourghi et al., 2007). In an indoor environment, if the dwelling receives solar heat, this can pose an increased energy demand on the cooling system for the provision of the desired level of thermal comfort. As expected, sun rays on a surface can result in heat gain, along with energy losses associated with the load on cooling equipment. Hence, the building shape can assist in determining the total areas of surfaces which are exposed. This can help in controlling the overall thermal performance.

The effects of socio-cultural factors and climatic regions of Iraq are the reason for the formulation of dwellings' shape. The literature shows that the introverted courtyard style is still the ideal type, given the weather conditions and cultural inclusiveness in Baghdad. Houses are usually rectangular or cubic in shape and courtyards reduce the area exposed to sun in summer and rain in winter. In a typical Baghdadi house, traditionally the vernacular courtyard house observes cultural values, with windows opening into the courtyard instead of facing the neighbourhood, thus facilitating increased control over the

physical form for the dwellers' comfort. The courtyard's influence in moderating temperatures and in enhancing air circulation to ensure adequate ventilation in kitchens, bathrooms and halls cannot be ignored. Also, vernacular houses' compact layout, along with their close proximity to each other, allows for protection of these houses from the rain in winter and sun in summer. The form of vernacular houses serves to modify the microclimate and maintain familial privacy, as the openings are directed to the courtyard; however, this is not the case in contemporary Baghdadi houses. The secret behind the success and uniqueness of the vernacular form of Baghdadi houses was that it brilliantly solved an equation that contains different environmental and social variables in a very advanced manner. None of the variables were ignored. However, in the case of contemporary Baghdadi houses, the issue is different. The shape of contemporary houses is not formed according to socio-cultural effects or bioclimatic regions. Contemporary houses are usually detached or semi-detached, with a larger surface area, which leads to greater exposure to solar radiation and wind than in vernacular houses; this gives these houses more solar energy, raising their thermal load. Furthermore, the newer house designs neglect the use of passive design techniques but depend mainly on mechanical systems. Today, houses in Baghdad do not represent the Baghdadis' vernacular styles in any way. With their new structures and shape, the residents' way of thinking in relation to their homes has changed. In Baghdad's latest constructions, the courtyard, which was once the core characteristic of the city's streets, is no longer the most important part of the house.

Bioclimatic analysis view: It was found that the most efficient passive strategies for the whole year for Baghdad are sun shading, natural ventilation, and evaporative cooling. With careful consideration, the shape of building as achieved by Baghdad's vernacular design strategies can support natural ventilation as well as self-shading.

Public survey views: The form of buildings in Baghdad was developed according to socio-cultural effects and as an appropriate response to bioclimatic regions. Though we cannot claim that these are the only reasons for the development of these building forms, the effects of sociocultural and climatic regions of Iraq cannot be neglected. However,

knowledge of these factors and their methods of application is not widespread. This highlights the need to inform people on the importance of building shape as an important characteristic in house design, especially in terms of wind and solar radiation. Governments must work in regulating the markets and promoting the need to adopt specific design strategies that should be considered when building future houses.

Expert survey views: The experts agreed that the shape of the building is an important aspect that needs to be considered. The experts believe that the optimal design of building shape is considered to be a very important (37%, 18/48) or important aspect (41%, 20/48).

Based on the experts' survey, the building shape criterion achieved a mean ranking of 4 out of 5, thus showing its importance. This appears to be applicable to Baghdad's current and future weather conditions, as well as taking into consideration the city's cultural requirements and the availability of local raw materials.

	Mean
Optimal design of building shape	4.06

Adoption in Design Strategies

Theme	Factor	Literature Review	Bioclimatic Analysis	Public Survey	Expert Survey	Adopt in Design Strategies?
Architecture design	**Form**	Y	Y	-	Y	Y

Guidance for Adoption of design strategy: Upon the planning and construction of new homes, the house form must be taken into consideration.

The table 7.5.a and b show the recommended design strategies for future house design in Baghdad.

Table 7.5.a: *The design strategies recommendations for architecture design factors\Form*

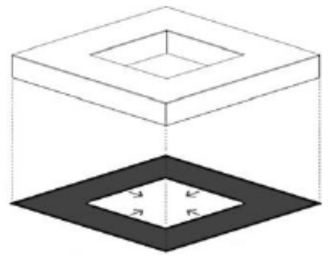
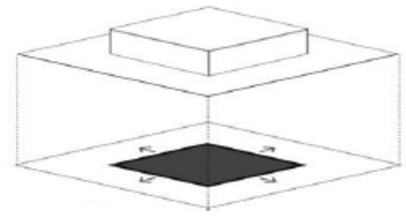
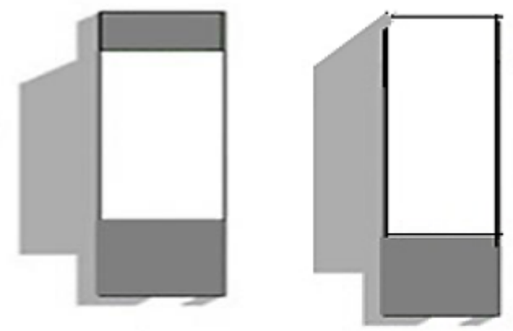
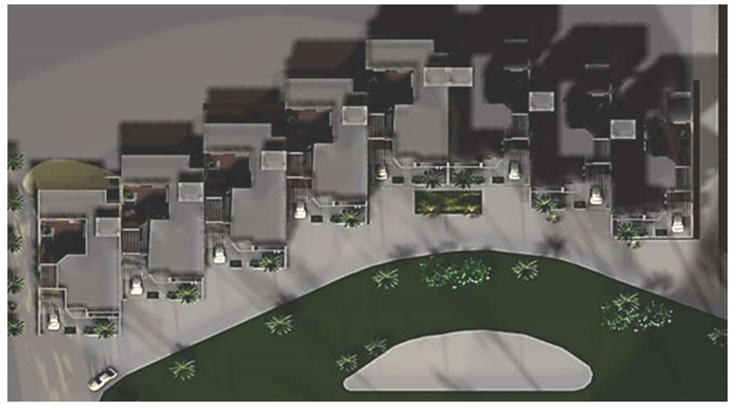
<table>
<tr><td>Design Strategy:</td><td>Architecture design factors</td><td colspan="2">Form</td></tr>
<tr><td rowspan="3">Drivers:</td><td>Market:</td><td colspan="2">Vernacular house</td></tr>
<tr><td>Passive:</td><td colspan="2">Shading+ Natural ventilation</td></tr>
<tr><td>Social:</td><td colspan="2">Provide private social gathering space for occupants</td></tr>
<tr><td>Objectives:</td><td colspan="3">• To reduce the exposed area to sun in summer and winter rains.
• To create shading from the solar gain, that is a key aspect to help cooling down the external surface, hence the internal cooling loads were reduced.
• To reduce heat-gain by compactness of the houses shape.</td></tr>
<tr><td rowspan="4">House shape in vernacular and contemporary house:</td><td rowspan="4">Vernacular courtyard house\Shape
• Reduce the exposed area to sun in summer and winter rains.
• Provide natural ventilation and shading.
• Comfortable level.
Contemporary house\Shape
• Like a box form - exposed to high solar radiation hence a high energy load is required to cool the inside to get a comfortable level.</td><td>Vernacular house</td><td>Contemporary house</td></tr>
<tr><td>
Source: Researcher</td><td>
Source: Researcher</td></tr>
<tr><td>
Source: Researcher</td><td>
Source: Researcher</td></tr>
<tr><td>The shape in the vernacular house with courtyard used to provide adequate shaded facades and also shaded the courtyard.</td><td>These shapes of contemporary houses are represented by a box-like form with unshaded facades, a similar concept of the typical house currently in Baghdad.</td></tr>
</table>

Table 7.5.b: *The design strategies recommendations for architecture design factors\Form*

<table>
<tr><td>Design Strategy:</td><td>Architecture design factors</td><td>Form</td></tr>
<tr><td rowspan="3">Drivers:</td><td>Market:</td><td>Vernacular house</td></tr>
<tr><td>Passive:</td><td>Shading+ Natural ventilation</td></tr>
<tr><td>Social:</td><td>Provide private social gathering space for occupants</td></tr>
<tr><td>Discussion</td><td colspan="2">Upon the planning and construction of new homes, the shape of a building must be considered because it is a key characteristic in the designing of a building, especially in terms of the winds and solar radiations. The introverted courtyard style is still the ideal type, considering their weather conditions and cultural inclusiveness in Baghdad, Iraq. The vernacular houses are usually rectangular or cubic in shape and courtyards reduce the exposed area to sun in summer and winter rains. Even with the use of grid layouts, there appear no main reasons for not making use of the same principles in contemporary design and planning. Hence, the courtyard style must be incorporated in the Baghdadi house environment.</td></tr>
<tr><td rowspan="2">Design strategy implementation example</td><td colspan="2">
Different options for adding courtyard in house design
Source: Researcher</td></tr>
<tr><td>• The shape of building as achieved by Baghdad's vernacular design strategies can support natural ventilation as well as self-shading.
• The proposed house form creates a shaded private outdoor space inside the house that provides for the important social need of Baghdadi families in Iraq for the daily activities and social gatherings. Also, the form creates a shaded façade that is a critical aspect to help cooling down the outside so the interior cooling loads are reduced finally.</td><td>

Source: Researcher</td></tr>
<tr><td>Implementation Needs</td><td colspan="2">• The market may require educating of the benefits of the shape of building because of an important characteristic in the house design, especially in terms of the winds and solar radiations.
• The courtyard design and its features should become compulsory for new buildings in the near future and also should be considered in the building code.
• The governments must work in regulating the markets and promoting the need for adopting specific design strategies that should be taken when building the future house.</td></tr>
</table>

7.2.2.2 Window design

Literature review: The literature has revealed that window design is yet another crucial aspect of the building that architects need to consider. Window design is extremely important to provide natural light as well as ventilation, and the location and size of windows is an important factor. It is a key feature for reducing solar gains and thereby reducing energy consumption.

The window (shanasheel) in vernacular houses was formed according to the sociocultural effects and as an appropriate response to climatic regions with the experience of centuries. Shanasheel was widely used in the facades of vernacular houses in Baghdad. They are an efficient feature in providing privacy and shade and encouraging air circulation by permitting the opening of windows while screening the occupants within. In the modern era, such functional and cultural purposiveness has been neglected. Thus, whereas the shanasheel was used both for functional and aesthetic purposes, its effect could be achieved by contemporary architecture, with the same cultural and environmental value. Certainly, there is a possibility to use shanasheel or technologically equivalent screening in houses to provide privacy as well as increasing control of window operating to maximise the comfort levels and to encourage air circulation. This feature could be installed as a projection on the first floor. In the modern era, windows in contemporary houses no longer provide shading; nor are they designed to deal with cross-ventilation or visual intrusion, as was the case in the vernacular house. Large, glazed, unshaded and visually unprotected windows have become a distinctive feature of the contemporary house, contributing to the high energy consumption in buildings.

***Bioclimatic analysis view*:** It was found that the most efficient passive strategies for the whole year for Baghdad are sun shading, natural ventilation, and evaporative cooling. With careful consideration, the window design (shanasheel) as achieved by Baghdad's vernacular design strategies can support natural ventilation as well as self-shading.

Public survey view: 76% (66/86) of the respondents from the contemporary houses and 83% (10/12) of the respondents from the vernacular houses chose to open windows to get cross air currents as a solution to escape high temperatures when air-conditioning is not

available. This indicates the importance of the windows' location and size in achieving suitable air movement. Moreover, 88% (86/98) of participants agreed that by implementing shades around windows or sources of light, houses may tend to remain cooler more naturally, automatically reducing energy demands for cooling, as the shading is analogous to placing a cap on the building to block the solar radiation from entering.

Expert survey view: As shown in chapter 6, the majority (79%, 38/48) of the respondents agrees that the window area should be reduced, while significantly decreasing the number of windows in the building. Additionally, 52% (25/48) of the sample respondents reflected that it is important (17%, 8/48) or extremely important (35%, 17/48) to have canopies attached to each window to protect from the sun (Table 6.12 and Figure 6.8). Participants were also asked whether it is necessary to use coloured glass for external windows. In response, 80% (38/48) of the sample thought that it was important (38%, 18/48) or very important (42%, 20/48), while none of them (0/48) indicated that it is not at all important (Table 6.12 and Figure 6.8). The results indicate that having smaller and fewer windows is vital to reduce the amount of heat that will enter the building, which will reduce energy demands for cooling. Moreover, the majority of the panel rated all of the ways of creating shade as important. The experts mentioned that the use of shading devices is essential in warm countries. This is because it protects the outer building by keeping it cool, which in turn reduces the use of air conditioners. The result showed that the shading device criterion achieved a mean ranking of more than 4 out of 5, thus indicating their importance, as set out in Tables 6.10 and 6.29 and Figure 6.6. As far as the shading devices are concerned, chapter 6 (Table 6.10 and Figure 6.6) indicated that 75% (36/48) of the respondents perceived that they were important (35%, 17/48) or very important (40%, 19/48). It is probably due to the fact that shading devices prevent or reduce direct sunlight entering the space. Also, a large portion of participants agreed that it is beneficial to use effective courtyard landscape design to provide shade around the building. Moreover, 69% (33/48) of the participants responded that it is very important (29%, 14/48) and important (40%, 19/48) to use sun louver techniques, while 63% (30/48) considered that shading by natural means is also an effective solution. The results underline that it is vital for buildings in Baghdad to have some sort of cover mechanism

to protect them from the sun. This will in turn minimize the use of air conditioners and thus reduce energy usage.

Based on the experts' survey, the highest five window design criteria achieved a mean ranking of more than 3.5 out of 5, thus showing their importance, as set out below. These appear to be applicable to Baghdad's current and upcoming weather conditions, as well as taking into consideration the city's cultural requirements and the availability of local raw materials.

		Mean
Window's Design	Reduce windows area	4.27
	Use color glaze for external windows	4.208
	Decrease the number of windows	4.16
	Growth of greenery	3.625
	Shelter the windows by the use of canopies	3.56
Shading device	Use roof shading techniques	4.59
	Use effective courtyard landscape designs for providing shading effects to the building	4.16
	Shading of Ventilated Façade	4.06
	use covers on the inside and outer windows to stop sun from going inside the building	3.95
	Use sun louver techniques.	3.85
	Using nature such as large trees to protect the home and provide protection from the sun	3.79
	Creating shading effect with horizontal canopies	3.5

Adoption in Design Strategies

Theme	Factor	Literature Review	Bioclimatic Analysis	Public Survey	Expert Survey	Adopt in Design Strategies?
Architecture design	**window**	**Y**	**Y**	**Y**	**Y**	**Y**

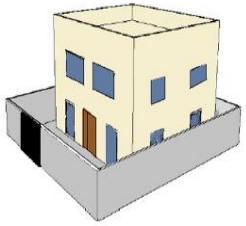
Guidance for Adoption of design strategy: Upon the planning and construction of new homes, the window design must be taken into consideration.

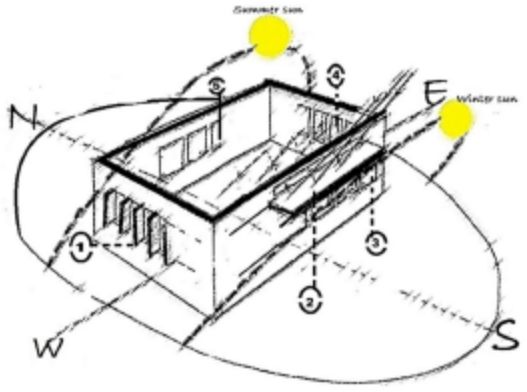
The table 7.6.a and b show the recommended design strategies for future house design in Baghdad

Table 7.6.a: *The design strategies recommendations for architecture design factors\Window design*

<table>
<tr><td>Design Strategy:</td><td>Architecture design factors</td><td colspan="3">Window design</td></tr>
<tr><td rowspan="3">Drivers:</td><td>Market:</td><td colspan="3">Vernacular house\Contemporary house</td></tr>
<tr><td>Passive:</td><td colspan="3">Shading+ Natural ventilation</td></tr>
<tr><td>Social:</td><td colspan="3">Provide privacy from outside</td></tr>
<tr><td>Objectives:</td><td colspan="4">• To provide natural light, shade and encouraging air circulation by permitting the opening of windows while screening the occupants within.
• To reduce solar gains and thereby reducing energy consumption.
• To provide privacy inside the building.</td></tr>
<tr><td rowspan="3">Windows design in vernacular and contemporary house:</td><td rowspan="3">Vernacular window design\ Shanasheel
• providing privacy and shade and encouraging air circulation by permitting the opening of windows while screening the occupants within.
Contemporary window design
• Large windows, large glazed unshaded facades, and glazing not spread evenly across orientations of a typical contemporary house.
• The unshaded facade is exposed to high solar radiation therefore a high energy load requires to cool the inside for a comfortable level.
• No privacy.</td><td>Vernacular window

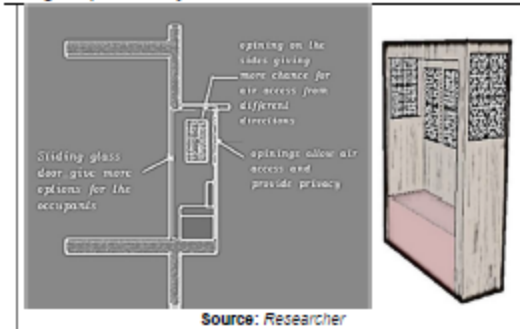
Source: Researcher</td><td colspan="2">Contemporary window

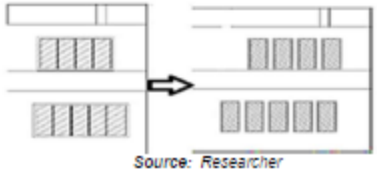
Source: Researcher
 
Source: Researcher</td></tr>
<tr><td>The vernacular shanasheel was a projected wooden screen that allowed air circulation and gave privacy while allowing inhabitants to see out and get cooling breezes. Also, provide shading to alleys.</td><td colspan="2">The contemporary house with large windows, large glazed unshaded facades.</td></tr>
</table>

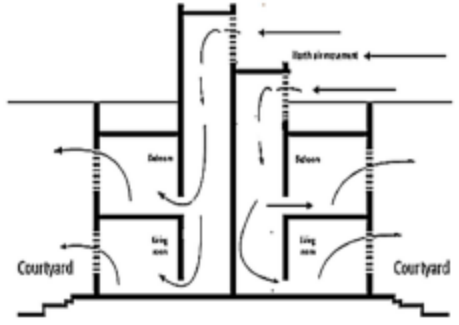
<table>
<tr><td>Design Strategy:</td><td>Architecture design factors</td><td>Window design</td></tr>
<tr><td rowspan="3">Drivers:</td><td>Market:</td><td>Vernacular house\Contemporary house</td></tr>
<tr><td>Passive:</td><td>Shading+ Natural ventilation</td></tr>
<tr><td>Social:</td><td>Provide privacy from outside</td></tr>
<tr><td>Discussion</td><td colspan="2">Upon the planning and construction of new homes, the location and size of windows should be considered because it is a key characteristic in the designing of a building, especially in terms of providing natural light as well as ventilation. The use of a large window is not appropriate. This is because the strategies propose the use of windows with reduced areas. In addition, to avoid solar heat penetration maximally, it is important to position the windows along northern facades. Windows on the western side, is the most vulnerable section of the dwelling to afternoon solar heat, due to the low angle of the sun, should be carefully treated to minimise solar exposure during these hours. Openings on the north and south could be protected from solar radiation by a small overhang. Encouraging ventilation through the provision of a small opening on a wall and another large opening on the opposite wall would accelerate air-movement and evaporative cooling (Koch-Nielsen, 2002; experts survey analysis\Chapter6) as was observed in the vernacular house. These strategies open the way for a future home environment with less energy consumption and higher levels of social interaction.</td></tr>
<tr><td>Design strategy implementation example</td><td colspan="2">


Shading the windows with suitable shading device (Source: Researcher)

On the west closely spaced vertical shades cut out the low evening sun. As the heat built up during the day in already present, minimization of openings is desirable.
Light shaves help in deeper penetration of daylight into the room & uniform distribution of daylight of lighting.
Large windows can be placed on the south sides as its relatively easier to shade the southern side from the high summer sun with a horizontal sun-shade. This can also be desirable winter sun.
Small windows on the east and west sides and must be adequately shaded.
Large windows could be placed on the north facade as direct solar radiation is least on this facade. Radiation from low sun peak summers can be cut off by small vertical shades.



Source: Researcher
Shanasheel, with a glass sliding door, provides privacy and gives more options to the residents Use the shanasheel or technologically equivalent screening in the houses to provide privacy as well as increasing control of windows operating to maximise the comfort levels and to encourage air-circulation. The shanasheel could be installed as a projection to provide shading and natural ventilation as well as provide privacy.

Source: Researcher
Replacing large windows with smaller windows providing the same area of the window, save cooling demand.

Source: Researcher
Cross ventilation depends on window or other opening on the opposite sides of the building being sufficiently opened which demands occupant to "operate" the building. Window or vent placed on the opposite sides of the house provide natural breezes a pathway through the structure.</td></tr>
<tr><td>Implementation Needs</td><td colspan="2">• Building laws should be modified by the government, changed and include strict rules that architects, designers and users should follow.</td></tr>
</table>

7.2.2.3 Windows glazing

Literature review: The literature revealed that a typical window in a vernacular house is constructed using a single pane of glass. It ranges from 3mm to 10mm in thickness and does not provide adequate insulation alone. The projecting oriel windows enclosed with lattices on the first floor of the house or higher are often lined with stained glass, thus providing sufficient insulation. This is a key feature for reducing solar gains and thereby reducing energy consumption while also providing natural light.

In the modern era, large glazed windows have become a distinctive feature of contemporary houses, contributing to the high energy consumption in buildings. The use of double glazing is common in some houses but the majority use single glazing. The problem with large glazed windows is that they are usually not protected from solar heat by using an appropriate shading device.

Bioclimatic analysis view: It has been identified that in order to achieve thermal comfort and reduce energy in Baghdadi buildings, sun shading, natural ventilation, and evaporative cooling should be considered, as well as minimizing heat gains. Most of the heat gains or losses in the buildings come from windows, which are the key element in the transfer of large amounts of heat between the building and the outside surroundings. Window insulation is determined by the space between the glass panels, which could be filled by either a vacuum or gas. Double glazing combined with a shading device could reduce energy consumption and achieve thermal comfort.

Public survey views: In total, 77% (75/98) (28%, 27/98 agree and 49%, 48/48 strongly agree) of the participants think that increasing the number of glass panes (i.e. using double or triple glazing) is necessary because this will play an important part in increasing the efficiency of the glazing to keep a temperature differential between the indoors and outdoors. An effective design for window glazing can contribute significantly to reducing solar heat gain. If successfully implemented, this can also reduce energy consumption.

Expert survey view: A total of 74% (41/48) (32%, 17/48 important and 42%, 20/48 very important) of the experts thought that the thickness of glass must be increased because this will play an important role in improving the efficiency of the glaze, while 4% (2/48)

reflected that this is not of importance. However, 81% (39/48) of the participants responded that it is very important (46%, 22/48) or important (35%, 17/48) to use a number of glazing panes (double/triple) and have air pockets between them to increase the efficiency of buildings in the country. In addition, 94% (45/48) indicated that it is very important (50%, 24/48) or important (44%, 21/48) to use highly airtight windows rather than the original frames as a feature of external glazing design.

Based on the experts' survey, the top three glazing design criteria achieved a mean ranking of 4 out of 5, thus indicating their importance, as set out below. These criteria appear to be applicable to Baghdad's current and upcoming weather conditions as well as taking into consideration the city's cultural requirements and the availability of local raw materials.

		Mean
Glazing design	Use highly air tight windows	4.437
	Use double/ triple glazing and have air pockets between them.	4.27
	Have more of a layer of thickness for the glazing	4.0

Adoption in Design Strategies

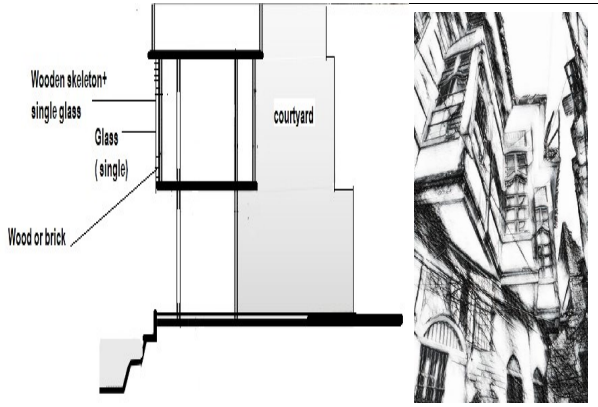
Theme	**Factor**	**Literature Review**	**Bioclimatic Analysis**	**Public Survey**	**Expert Survey**	**Adopt in Design Strategies?**
Architecture design	**Glazing**	Y	Y	Y	Y	Y

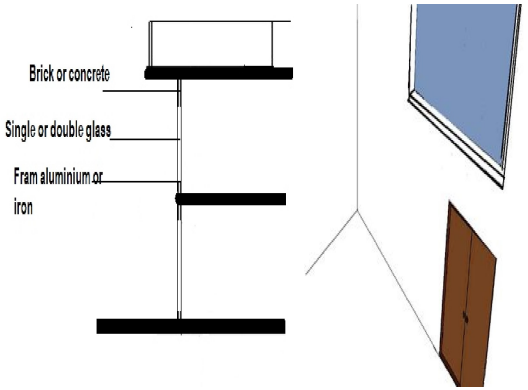
Guidance for Adoption of design strategy: Upon the planning and construction of new homes, the window glazing must be taken into consideration.

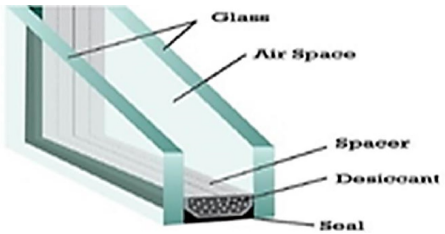
The table 7.7 shows the recommended design strategies for future house design in Baghdad.

Table 7.7: *The design strategies recommendations for architecture design factors\Window glazing*

<table>
<tr><td>Design Strategy:</td><td>Architecture design factors</td><td colspan="2">Window glazing</td></tr>
<tr><td rowspan="3">Drivers:</td><td>Market:</td><td colspan="2">Contemporary house</td></tr>
<tr><td>Passive:</td><td colspan="2">Reducing solar gains</td></tr>
<tr><td>Social:</td><td colspan="2">Provide privacy\ Opaque glass</td></tr>
<tr><td>Objectives:</td><td colspan="3">• To reduce heat loss from room and thereby reducing energy consumption.</td></tr>
<tr><td>Window glazing in vernacular and contemporary house:</td><td>Vernacular glazing:
• Single glaze with wooden skeleton

Contemporary glazing:
• Large windows, large glazed unshaded facades of a typical contemporary house.
• The majority use single glazing.
• Double glazing is common in some houses.</td><td>Vernacular house


Shanasheel \ wood + single glass (colour or clear)
Source: Researcher</td><td>Contemporary house


Window\ glazing (single or double+iron or aluminium fram
Source: Researcher</td></tr>
<tr><td>Discussion</td><td colspan="3">An effective design for window glazing can contribute significantly in order to reducing energy consumption (Gasparella et al., 2011, Pisello et al., 2012, Jelle, 2013). Several applicable techniques in Baghdad for external window glazing designs have been scrutinized and discussed followed by approval from experts. Multiple glazing approaches in Baghdad's hot climate are significant. However, this approach can be more suitable if used together with reduced sizes of external glazed panels. Moreover, poor design of external single glazing was found by researchers to be the main reason for increased energy consumption in existing homes in Iraq (Al-Jawadi, Miqdad et al, 2001). Overall, there appears to be inadequate incentives for using effective designs for house envelopes along with extra external glazing because of the low price, electricity tariff in the domestic sector in Iraq. Ensuring any air leakages are kept minimal for preventing draughts is important when designing an ideal house. In order to prevent heat- gain in summers while retaining heat in winters, it is essential to use insulation in the wall and roofs. Also, to ensure effective heating of indoor spaces, a more compact form is appropriate. Moreover, a reduction in energy consumption is possible with an effective design of external window glazing.</td></tr>
<tr><td>Design strategy implementation example</td><td>• Use double glazing. Technically triple glazing better, but the social factor effects for not including (e.g. lack of availability).
• Shading the windows with suitable shading device, as mentioned in Table 7.6, combine with double glazing to minimize of heat gains</td><td colspan="2">

Source: https://www.royalglassindia.com/insulated-glass.html</td></tr>
<tr><td>Implementation Needs</td><td colspan="3">• Building laws should be modified by the government, changed and include strict rules that architects, designers and users should follow.</td></tr>
</table>

7.2.2.4 Envelope design

Literature review: The literature revealed that the thermal function of the house envelope is to resist heat transference, reflecting as many sun rays as possible to minimise solar and heat gain in order to create cool conditions inside and counteract the excessive solar gain. The exterior walls of the vernacular house are constructed using traditional and local materials suited to climatic conditions (such as mud bricks or stone with thickness between 50 cm and 75 cm). These construction materials and the thickness of the walls increase heat storage and delay heat transfer at night. However, the exterior walls of contemporary houses, made of bricks or concrete with a thickness of 24 cm, do not provide sufficient thermal insulation or storage; nor do they delay heat transfer.

Bioclimatic analysis view: The three key passive strategies for the whole year for Baghdad have been identified as sun shading, natural ventilation, and evaporative cooling. Also, the building envelope can significantly reduce heat gain, as the insulating materials in walls and roofs are very beneficial for energy efficiency.

Public survey views: The building envelope of adequate thermal resistance is essential to provide energy efficiency and human comfort. However, the knowledge of this and its methods of application are not widespread. This highlights the need to inform people on the importance of the building envelope because it can be considered as a selective path for building, working with the climate and responding to the needs for cooling, heating, ventilation, and lighting. Government institutions such as the Mayoralty of Baghdad must work to regulate the markets and promote the need to adopt specific design strategies that should be applied when building future houses.

Expert survey view: The professionals were of the opinion that it is vital to have a building envelope which protects the interior from the heat outside. An example of this is using material that has low conductivity, because the thicker the material, the more likely it is to reduce the U-value of the building outside.

Based on the experts' survey, the highest house envelope design criterion achieved a mean ranking of more than 3.5 out of 5, as shown below. These appear to be applicable to

Baghdad's current and upcoming weather conditions as well as taking into consideration the city's cultural requirements and the availability of local raw materials.

			Mean
House envelope design	Building envelope	Type of Insulation materials	4.52
		Resistance of the materials	4.416
		Utilise the correct materials in order to keep coolness in the building	4.40
		materials Conductivity	4.395
		Thickness of the house envelop(wall, roof, and floor)	4.27
	External Walls	build double walls for the outside	4.33
		Use wall materials with good insulation properties.	4.31
		Usage of cavity methods on the outside walls (they will act as air ducts for heat-exchange reasons)	4.21
		Using solid clay brick for designing exterior walls	4.0
	External Roof	Using good insulation materials and concrete when building the roof outside above the concrete	4.27
		A gap can be made above the structure which could stop direct heat coming in at night. This would be due to efficient ventilation	3.5

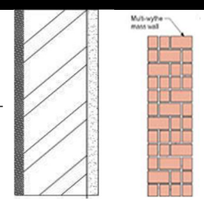
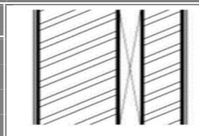
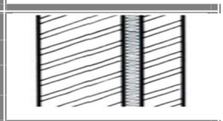
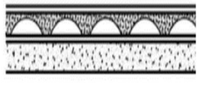
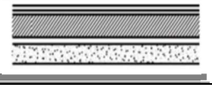
Adoption in Design Strategies

Theme	Factor	Literature Review	Bioclimatic Analysis	Public Survey	Expert Survey	Adopt in Design Strategies?
Architecture design	**Building envelope**	Y	Y	-	Y	Y

Guidance for Adoption of design strategy: Upon the planning and construction of new homes, the building envelope must be taken into consideration.

The table 7.8 shows the recommended design strategies for future house design in Baghdad.

Table 7.8: *The design strategies recommendations for architecture design factors\Building envelope*

<table>
<tr><td>Design Strategy:</td><td>Architecture design factors</td><td colspan="3">Building envelope</td></tr>
<tr><td rowspan="3">Drivers:</td><td>Market:</td><td colspan="3">Vernacular house\Contemporary house</td></tr>
<tr><td>Passive:</td><td colspan="3">Reducing solar gains</td></tr>
<tr><td>Social:</td><td colspan="3">-</td></tr>
<tr><td>Objectives:</td><td colspan="4">• To reduce heat loss from room and thereby reducing energy consumption.</td></tr>
<tr><td>Envelope building in vernacular and contemporary house:</td><td>Vernacular house:
• Use thick brick
Contemporary house:
• Use bricks or concrete - - do not provide sufficient thermal insulation nor storage or delay heat transfer.</td><td colspan="2">
<table>
<tr><td rowspan="2">Wall</td><td>Brick thick\ 50cm</td><td>Wooden skeleton + glass</td><td>Brick + Timber joints</td></tr>
<tr><td colspan="3">Wooden skeleton + brick filling+ glass</td></tr>
<tr><td>Roof</td><td>30 cm clay+ straw</td><td>5cm Straw</td><td>20cm wood</td></tr>
</table>
</td><td>
<table>
<tr><th></th><th></th><th>Thickness mm</th><th>Conductivity W/m².K</th><th>U-values W/m².K</th><th>Section + Elev.</th></tr>
<tr><td rowspan="3">Exterior wall layers</td><td>Stucco</td><td>20</td><td>1.35</td><td rowspan="3">2.65</td><td rowspan="5"></td></tr>
<tr><td>Brick</td><td>130</td><td>0.85</td></tr>
<tr><td>Plaster - dense</td><td>20</td><td>0.5</td></tr>
<tr><td rowspan="5">Roof Layers</td><td>Ceramic clay tiles</td><td>300</td><td>1.4</td><td rowspan="5">2.25</td></tr>
<tr><td>Cement screed</td><td>300</td><td>1.4</td></tr>
<tr><td>Asphalt mastic roofing</td><td>200</td><td>1.15</td></tr>
<tr><td>Concrete – reinforced with 2% steel</td><td>150</td><td>2.5</td></tr>
<tr><td>Plaster - dense</td><td>20</td><td>0.5</td></tr>
<tr><td colspan="4">Single Glazing windows with Iron frame</td><td>4.8</td></tr>
<tr><td colspan="5">Reference: CIBSE Guide A</td></tr>
</table>
</td></tr>
<tr><td>Discussion</td><td colspan="4">The energy consumption is very high in existing buildings in Bagdad; therefore, it is a necessity to build a house with an envelope as in some areas, the temperature rises to more than 46°C. The cooling load increases significantly due to high temperatures and as a result, high energy is required to cool the rooms properly and provide comfort. The proposed design strategies in this research can be used as a reference when housing envelopes will be designed, and raw material availability must be considered.</td></tr>
<tr><td>Design strategy implementation example</td><td>The materials choice optimize between insulation provided + the embodied energy of materials depend on its local availability.</td><td colspan="2">
<table>
<tr><th></th><th>Materials</th><th>Thickness mm</th><th>U-values W/m².K</th><th></th></tr>
<tr><td rowspan="4">Wall 1</td><td>Brick work wall</td><td>230</td><td rowspan="4">0.95</td><td rowspan="4"></td></tr>
<tr><td>Air gap</td><td>70</td></tr>
<tr><td>Brick work wall</td><td>115</td></tr>
<tr><td>Plaster-dense\both side</td><td>12</td></tr>
<tr><td rowspan="4">Wall 2</td><td>Brick work wall</td><td>230</td><td rowspan="4">2.51</td><td rowspan="4"></td></tr>
<tr><td>XPS</td><td>50</td></tr>
<tr><td>Brick work wall</td><td>115</td></tr>
<tr><td>Plaster \both side</td><td>12</td></tr>
<tr><td rowspan="3">Roof 1</td><td>RCC slab</td><td></td><td rowspan="3">0.60</td><td rowspan="3"></td></tr>
<tr><td>Inverted earthen pot in lime concrete</td><td>75</td></tr>
<tr><td>Cement mortar finish</td><td>20</td></tr>
<tr><td rowspan="3">Roof 2</td><td>RCC slab</td><td></td><td rowspan="3">0.39</td><td rowspan="3"></td></tr>
<tr><td>Brickbat coba</td><td>50(avg.)</td></tr>
<tr><td>Cement mortar finish</td><td>20</td></tr>
</table>
</td></tr>
<tr><td>Implementation Needs</td><td colspan="4">• Professional training to use technology and developed building materials with more attention to using thermal insulation.
• Government must provide codes related to building materials.
• Encourage scientific researchers to develop local materials as well as produce building materials at a suitable cost.</td></tr>
</table>

7.2.2.5 Roof terrace

Literature review: The literature revealed that the vernacular house offers complete privacy to inhabitants as a sleeping area during the summers. The parapet wall and its height prevent neighbours from peeking. However, the roof terraces in contemporary houses do not offer inhabitants complete privacy for sleeping at night in summers. The parapet wall and its height do not prevent neighbours from peeking. Also, the area of the contemporary house roof is big enough to do various activities, but tends not to be used in this way at all.

Bioclimatic analysis view: It was found that the most efficient passive strategies for the whole year for Baghdad are sun shading, natural ventilation, and evaporative cooling. Roof shading reduces or cuts off solar radiation from the roof area (reducing heat gain), and reduces cooling load, since the roof is not exposed to the sun throughout the entire operating day. Also, using jaalis in the roof parapet allows air movement above the hot roof, relatively cooling it down during the daytime and increasing the speed of heat loss at night.

Public survey views: Roof terraces can be repurposed or redesigned for more practical application. In total, 45% of participants strongly agreed that the roof terrace could be used for sleeping in the summer. Conversely, 27% (26/98) of respondents disagreed with this, due to the walls not being tall enough to prevent peeking. Hence, taller walls could possibly satisfy residents' needs.

Moreover, 32% (31/98) of participants agreed and 45% (44/98) of participants strongly agreed that householders must install PV systems to generate electricity in their homes. This tends to be achieved through using rigid panels fixed onto the roof surface.

Expert survey views: Use of the roof terrace as a sleeping space during the summer nights and for different activities was supported by experts, who confirmed that such terraces could satisfy the inhabitants' needs and provide them with complete privacy if the parapet wall of the roof was high enough to prevent them from being overlooked by neighbours. In total, 69% (33/48) of experts suggest that the roof terrace could be used as a sleeping space during summer nights and for other activities. On the other hand, 4%

(2/48) of respondents indicated that this is not an important factor, and explained that this was because the walls were not high enough to prevent neighbours from looking over.

Moreover, 50% (32/48) of the participants thinks that it is very important (19%, 9/48) or important (31%, 15/48) to use the PV panels on the tops of south-facing buildings. For buildings facing any other direction other than south, 61% (29/48) of the participants think that it is very important (15%, 7/48) or important (46%, 22/48) to move the PV to face the eastern and western sides, as this will enable electricity to be generated using solar energy. In addition, 71% (34/48) of the sample participants responded that it was important (31%, 15/48), or very important (40%, 19/48) to use solar radiation to heat water: this proved to be the most agreed upon option.

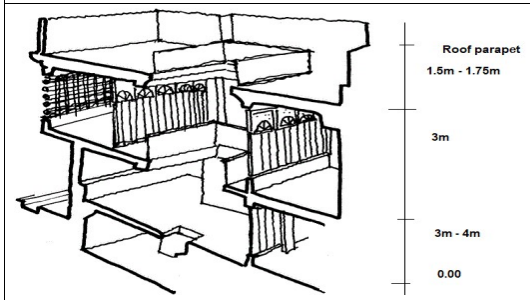
Adoption in Design Strategies

Theme	**Factor**	**Literature Review**	**Bioclimatic Analysis**	**Public Survey**	**Expert Survey**	**Adopt in Design Strategies?**
Architecture design	*Roof terrace*	Y	Y	Y	Y	Y

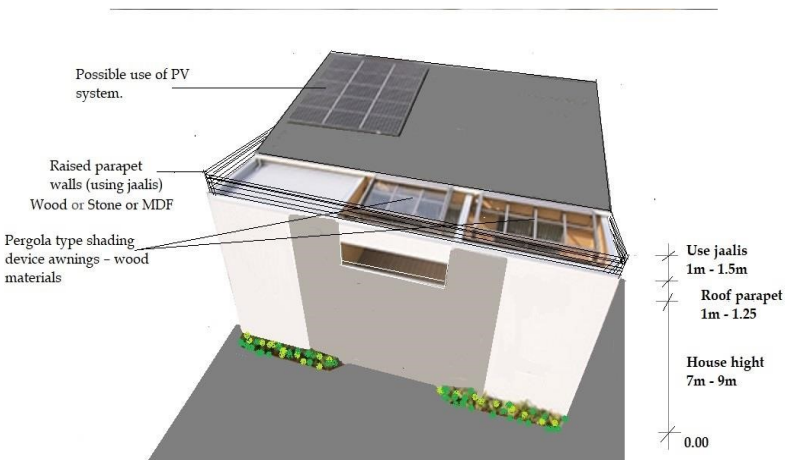
Guidance for Adoption of design strategy: Upon the planning and construction of new homes, the roof terrace design strategy must be taken into consideration.

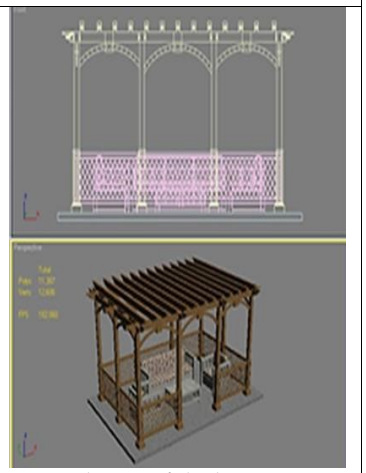
The table 7.9 shows the recommended design strategies for future house design in Baghdad.

Table 7.9: *The design strategies recommendations for architecture design factors\ Roof terrace*

<table>
<tr><td>Design Strategy:</td><td>Architecture design</td><td colspan="2">Roof Terrace</td></tr>
<tr><td>Drivers:</td><td>Market:</td><td colspan="2">Vernacular house</td></tr>
<tr><td></td><td>Passive:</td><td colspan="2">Shading+ natural ventilation</td></tr>
<tr><td></td><td>Social: :</td><td colspan="2">Provide privacy</td></tr>
<tr><td>Objectives:</td><td colspan="3">To reduce solar gains to roof.
To provide privacy for summer time sleeping on the roof.</td></tr>
<tr><td>Roof terrace in vernacular and contemporary house:</td><td>Vernacular roof
Flat roof- use in summer sleeping/ The parapet wall and its height prevent neighbours from peeking.
Contemporary roof
Flat roof – little or no access / No privacy / No shading\ The parapet wall and its height do not prevent neighbours from peeking.</td><td>Vernacular house


Source: Researcher</td><td>Contemporary house


Source: Researcher</td></tr>
<tr><td>Discussion</td><td colspan="3">Upon the planning and construction of new homes, the taller walls could be possibly satisfied with residents' needs in the future house to provide privacy in terms of preventing neighbours overlooking.</td></tr>
<tr><td>Design strategy implementation example</td><td>• Raised parapet walls (using jaalis)
• Materials – wood but can use stone or currently replaced with MDF
• Pergola type shading device awnings – wood materials
• Also, possible use solar patio cover.
• Possible use of PV system.</td><td colspan="2">

Source: Researcher

Pergola type of shading
Source: 3D MAX Libraries</td></tr>
<tr><td>Implementation Needs</td><td colspan="3">Professional training to encourage them to use passive design techniques such as sun shading, solar panels, and increase the height of roof walls to provide privacy and reduce solar gain.</td></tr>
<tr><td></td><td colspan="3">Market transformation about the significant financial benefits of roof techniques and solar panel to reduce the costs of energy bills and its great future impact.</td></tr>
</table>

7.3 Achieved Design Strategies

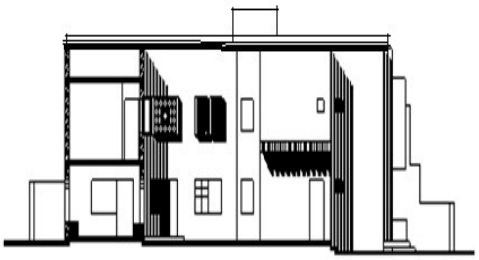
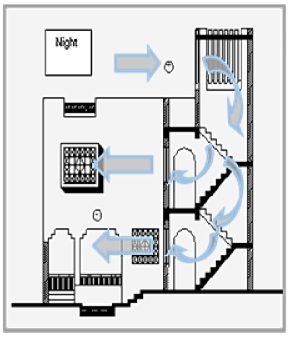
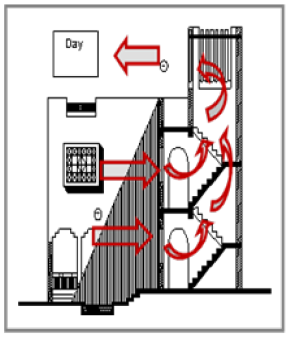
With the aim of establishing a set of appropriate design approaches to inform future housing design in Iraq, which can enhance comfort levels yet decrease energy usage along with cultural responsiveness, a series of significant factors have been evaluated and identified. Four stages were utilised to investigate design strategies in Baghdad, literature review, the bioclimatic analysis, public survey view, and the experts survey view. As a result, the researcher has suggested that a mix of positive characteristics from the vernacular house and the contemporary house should be applied to future design strategies for a synthesised house design for Baghdad to provide better and naturally welcoming housing solutions that are able to satisfy functional expectations and social needs.

Table 7.10 and 7.11 analysis and summarize the design strategies recommendations obtained by each phase.

Table 7.10: *The design strategy recommendations obtained by each theme*

Design strategy		Direct impact	Design solution
Urban fabric aspects	Compactness and street layout	Shading and Natural ventilation	**Compactness** Walkability
		Natural ventilation	Wider street/ Car access
		Shading and Natural ventilation	Trees or palms
	Orientation	Heat gain and Natural ventilation	N-S
	Outside zone	Shading, Natural ventilation, Evaporative cooling and Heat gain	Courtyard
			Trees, plants and fountains
Architecture design aspects	Form	Shading, Natural ventilation and Heat gain	
	Window design	Natural ventilation and Shading	Size of window
			Shading device
	Glazing design	Heat gain	
	Envelope design	Heat gain	Materials
	Roof terrace design	Sun shading and Natural ventilation	

Table 7.11: *The recommended house design strategies recommendations obtained by each theme(Researcher)*

Design strategies		Design solution
Urban fabric aspects	Compactness and street layout	
	Orientation	  
	Outside zone	  
Architecture design aspects	Form	
	Window design	
	Glazing design	
	Envelope design	
	Roof terrace design	

7.4 Conclusion

To establish appropriate design strategies to inform future housing design in Iraq, which can enhance comfort levels yet decrease energy usage while remaining culturally responsive, a series of significant factors have been evaluated and identified. Four stages were utilised to investigate design strategies in Baghdad, namely a literature review, a bioclimatic analysis, a survey of public views, and an expert survey. As a result, the researcher suggests that a mix of advantageous characteristics from vernacular houses and contemporary houses should be applied to future design strategies for a synthesised house design for Baghdad to provide better and naturally welcoming housing solutions that can satisfy functional expectations and social needs. Urban fabric and architecture design factors have been achieved as a future design strategy for a synthesised house design for Baghdad.

7.5 Recommendations for application of research from chapter seven

The following recommendations have been derived from the key findings of the research:

For designers and architects

To improve future design, architects and designers should consider the following strategies:

- Architects and designers should consider energy efficiency in their design concept. By considering sustainable design techniques at the early stages of conceptual design stage a great level of energy saving can be achieved during the operation stage;
- Apply sustainable design and climatic design strategies at the design stage;
- The urban design plan should consider the need for a car;
- The compact layout reduces the surface area available for solar radiation, however, narrow streets are not necessarily beneficial for cars and other transport systems. Consequently, if wider streets are provided, it is recommended that trees and shading elements are used with them;
- Use vernacular features in a modern way such as the courtyard idea with some modifications, as well as other features such as shanasheel, in Baghdadi houses in the future in a careful way;

- Provide good orientation; buildings orientated towards the north-south axis are potentially more efficient than east-west orientation;
- Study openings' sizes and position;
- Reduce the amount of surfaces facing the direct sun by shading (by the building itself and by shading devices such as trees and vegetation);
- The longest elevation should face north and south;
- Ensure there is internal cross-ventilation;
- Consider the need for thermal resistance;
- Use technology and developed building materials with more attention to using thermal insulation;
- Respect the public's behaviour, lifestyle changes, and the needs of individuals towards comfort which include thermal, functional, visual and safety aspects;
- Reduce energy consumption by using passive design techniques such as sun shading, solar panels, and double walls, as well as by increasing the height of internal walls with upper openings to allow hot air to exit.

For public awareness

To improve housing, users should consider the following:

- Reduce dependence on air conditioning to achieve internal thermal comfort by using passive strategies;
- Be aware of the concepts and benefits of sustainable design and low-energy design;
- Respect and know the building regulations;
- Understand the significant financial benefits of energy efficiency techniques to reduce the costs of energy bills and its great future impact.

For government's

- Building laws should be modified and changed and include strict rules that architects, designers and users should follow and so reduce the number of inappropriate procedures;
- The current building design approval system does not include the energy efficiency requirements for buildings: this needs to be revised;

- The passive design strategies suitable for the Iraqi region should become compulsory for new buildings in the near future and also should be considered in the building code;
- Implement housing projects with sustainability and low-energy design as well as encourage people to use them and experiment with them to also convince people of the benefits. These projects should develop continuously. In addition, use the media to convince people to accept sustainable and low-energy designs;
- Provide institutes for training skills;
- Provide competitions to select the best projects and test these projects by people who can measure benefits and drawbacks;
- Provide codes related to building materials;
- Ensure architects and designers are included in the design process and organize professional practice;
- Promote a positive change in housing through using the opinions of committed architects, designers, engaging owners and occupiers of such houses;
- Encourage groups that will agree to the protection of Iraqi vernacular design;
- Encourage scientific researchers to develop local materials as well as produce building materials at a suitable cost.

8.1 Introduction

Over the last three decades, most importantly post 2003, Iraq has undergone significant cultural, societal, economic and environmental changes. One aspect of this has involved significant changes to dwelling design. There is concern that current dwelling designs are not appropriate to current cultural and environmental requirements. This research aims to establish a set of appropriate design approaches to inform future housing design in Iraq, which can enhance comfort levels yet decrease energy usage along with cultural responsiveness. Therefore, this study has considered the advantages of passive designs and vernacular courtyard houses for future architectural buildings in terms of both the local environment and cultural responsiveness.

The earlier chapters have shown the main findings of this study and provided sets of design strategies for new housing units in Baghdad, as a case study. Suitable design strategies require combinations of contemporary technology with passive design fundamentals to provide better and naturally welcoming housing solutions that can satisfy functional expectations as well as social needs. This chapter provides the main conclusions of this study, presenting those for the research aim and each objective, a summary of the key contributions to knowledge, limitations fo the study as well as recommendations for further research work.

8.2. Conclusion

The following objectives were established to support the achievement of the research aim stated in Section 8.1.

Objective 1: *Identify and analyse feasible passive strategies for application in Baghdadi climate;*

Objective 2: *Examine the levels of householders' (public) satisfaction with both, contemporary and vernacular houses with regards to their environmental (comfort and energy) and cultural performance;*

Objective 3: *Explore the perceptions of built environment professionals relating to design and construction of modern housing units and their incorporation of passive strategies in Baghdad;*

Objective 4: *Propose a framework for design strategies for new housing units in Baghdad, that appropriately combines contemporary technology with passive design fundamentals in order to provide comfortable and energy efficient housing solutions that are able to satisfy householder's functional expectations as well as social and cultural expectations and needs.*

Objective 1 to *identify and analyse feasible passive strategies for application in Baghdadi climate* was achieved by **bioclimatic analysis,** reported in **chapter 4**. From this research it was found that the most efficient passive strategies for the whole year in Baghdad are solar shading of windows, natural ventilation and direct evaporative cooling. However, it has been identified that at some times in order to achieve comfort, cooling with dehumidification as well as heating with added humidification are required. The results presented here concentrate on winter and summer, as these seasons are highly challenging with regards to thermal comfort. All these strategies can be incorporated within a building to achieve as many hours as possible of comfort, energy saving, and enhanced low-energy use in the climate of Baghdad.

Table 8.1 shows the summary findings from the analysis of hours of comfort achieved by specific passive design strategies based on bioclimatic analysis for Baghdad.

Table 8.1: *Finding from the analysis of hours of comfort achieved by specific passive design strategies based on bioclimatic analysis for Baghdad*

Passive Strategies	
Cooling	Sun shading of windows
	High thermal mass
	High thermal mass night ventilation
	Direct evaporative cooling
	Natural ventilation cooling
Heating	Passive solar direct gain low mass
	Passive solar direct gain high mass
	Wind protection of outdoor spaces

It was found that there are 1531 hours (17.5%) of a year that do not need heating or cooling. With the most significant passive design strategies for summer include Shading, high thermal mass at night, High thermal mass, Direct Evaporative cooling, and Natural ventilation cooling. While, in the colder Winter season, the main passive design strategies are Passive Solar Direct Gain Low Mass and High Mass. At times, sun shading strategies are still also required in winter, providing a design challenge for their appropriate and

flexible design. It is acknowledged that mechanical services may be needed in some months to achieve comfort where passive strategies are not sufficient, although their specification is outside of the scope of this work (Chapter 4\Figure. 4.6 and Table 4.5).

The results discussed in this research indicate that the most efficient passive strategies for the whole year for Baghdad are the solar shading of windows, natural ventilation, direct evaporative cooling, and heating along with added humidification if required. These design strategies, theoretically identified as suitable for Baghdad by this study, have previously been adopted in one form or another since ancient times. Table shows 8.2 a comparative of the results of implementing the passive design strategies identified in bioclimatic analysis and the findings from the literature reviews, as to vernacular application of passive strategies.

Table 8.2: *A comparative of the results of implementing the passive design strategies identified in bioclimatic analysis and literature reviews.*

Bioclimatic analysis	***Literature reviews***	
Passive design strategies	*Passive strategies in vernacular architecture*	*Houses' elements or features*
Shading	Shading	Compact layout
		The courtyard
		The building form
Natural ventilation	Natural ventilation	The courtyard
		The internal spaces
		The wind – tower(Badgir)
		The building form
		The water& planting features
Evaporative cooling	Evaporative cooling	The courtyard
		The water& planting features

All these strategies can be incorporated within a building to achieve optimized hours of comfort, through passive design, resulting in energy saving, and enhanced low energy use in the climate of Baghdad.

Objective 2, to *examine the levels of householders' (public) satisfaction with both, contemporary and vernacular houses with regards to their environmental (comfort and energy) and cultural performance;* was achieved through **a survey developed and provided to occupants of both vernacular and contemporary houses** and reported in **chapter 5**.

In this research, the respondents' satisfaction with both contemporary and vernacular houses with regards to environmental and cultural performance were examined. This can be seen as a proxy for the market for the market's satisfaction with housing provision as well as its interest in the use of vernacular strategies in the future of contemporary housing.

The review of the findings has demonstrated the achievements of vernacular and contemporary housing typologies in Baghdad. Both of which have benefits associated with the features embedded in each dwelling typology. Indeed, any requirements which are not fulfilled by one typology were typically found to have been successfully addressed by the other. This indicates a market interest in a future synthesis design of housing for Baghdad.

The contemporary house in Iraq, Baghdad, has been found to rely significantly on mechanical services (particularly air conditioning) which is no longer sustainable. Contemporary homes have also been found to fail in their responsiveness to cultural requirements (e.g. privacy and community). They are not able to fulfil these social requirements of the residents; hence, it is extremely important to understand how these needs may be met. Moreover, walkability and good socializing opportunities were found to be the positive results of the compact vernacular layout. However, in contemporary areas, the wide streets allowing cars and direct access to the house were also found to be positive results satisfying different and more modern requirements. Design strategies that meet and balance these two needs are thus required.

In terms of ***environmental characteristics***, the vernacular houses in Baghdad were reported as responsive to the climate, by their occupants, confirming the value and impact of the climate's strong influence on the design of these homes, as confirmed in both the literature and bioclimatic analysis. The integrated passive design strategies of vernacular houses, such as natural ventilation and sun shading, thus compares favorably with the dependence on active systems found in contemporary houses, in terms of running costs,

energy efficiency and thus environmental sustainability. This is perhaps reflected in the respondents' satisfaction with their homes ability to meet their needs in summer, where the findings show that 48% (41/86) of respondents in contemporary houses were ***not satisfied*** whereas 91% (11/12) ***were satisfied*** with vernacular houses.

Furthermore, in terms of the ***sociocultural characteristics***, the research showed that vernacular dwellings satisfy sociocultural requirements for the people by providing inhabitants with complete privacy. This is in contrast to the design of contemporary homes, that was not considered to meet these requirements in particular in terms of preventing overlooking by neighbours.

Finally, despite the limited public awareness of the ***communal perceptions and awareness on low energy houses***, sustainable, low energy homes, together with a perception of social-cultural barriers to the delivery of low energy homes and large scale retrofitting of existing domestic stock. It was found that 84% (83/98) of all the respondents preferred to live in houses that consisted of a combined house style; that is, a style containing both traditional and modern features and including modern technology. These results show that the respondents are likely to accept the final guidelines where solutions will be suggested that promote a synthesis of both vernacular and contemporary architecture with embedded passive strategies for comfort.

Objective 3, to *explore the perceptions of built environment professionals relating to design and construction of modern housing units and their incorporation of passive strategies in Baghdad*; was achieved by **analysis of expert knowledge for designing new housing in Baghdad using a combination of questionnaires and analysis of the responses and reported in chapter 6**.

In this research experts' perceptions of the potential for inclusion of passive design strategies in future Baghdadi housing designs were also evaluated. The interviews for experts offered rich in-depth perceptions as well as understandings of the many issues that surround the move towards modernity and away from vernacular in Iraqi, Baghdadi, houses. It also added discussions for the prospective of the use of traditional vernacular elements in today's houses. This represents a proxy measure for the capacity of the construction industry and in particular its profession representatives to deliver integrated passive and socio-cultural design strategies with a synthesised future housing design

typology for Baghdad. The most significant conclusions from this aspect of the study are presented:

In terms of ***architectural design characteristics***, it was found that the use of courtyards was recognized as the best traditional vernacular component. When asked about issues facing the contemporary house, most professional participants specifically identified the lack of a courtyard. Moreover, the participants recognized the courtyard as the key traditional vernacular element that they sought to embed in house design. This reinforces how people directly relate the courtyard to the vernacular style, as well as confirming the confidence of these professionals in their application.

When asked whether vernacular elements should be used in contemporary houses, 85% (41/48) of experts said yes. However, when asked there are vernacular elements currently in their house 42% (20/48) of experts said no. The question then arises, if people desire the applications of these elements why are they not used in their current houses? The findings revealed contradictions in expert participant's responses, which suggests disconnects in understandings and in particular application and synthesis between vernacular and contemporary design. Conversely, when asked to identify the key issues facing contemporary homes in Baghdad, responses could be categorized as: socio cultural; environmental sustainability; commercial\ government's role; and spatial issues.

In terms of describing ***the problems that face contemporary house, expert*** participants primarily discussed ***socio-cultural issues***. with vernacular houses described as being "hospitable", with the design of adjacent houses served to build, and strengthen social fabrics through family and neighbourhood bonds. Its simple design provided people's basic needs and maintained cultural norms and privacy. In contrast when describing the contemporary house expert participants usually expressed a negative tone referring to the new houses as being "unfriendly". Although heavily discussed by experts, when asked if vernacular elements should be applied in contemporary houses; culture was ranked first by experts (31%, 15/48); followed by environmental sustainability (27%, 14/48). However, when expert participants were asked to rank the importance of factors in designing their house, culture ranked the third (19%, 9/48) behind the environmental sustainability (35%, 17/48) and identity (31%, 15/48). Participants do perceive traditional vernacular components as expressions of environmental sustainability as well as cultural

importance. However, it is then questionable as to why these participants do not implement these significances in their dwelling designs. This may mean that while experts value and recognize their cultural identities as residents, they may not prioritise or express their views in the built environments that they develop, design and influence.

In terms of ***environmental characteristics***, the research results reveal that vernacular houses are perceived, be expert respondents to be more environmentally sustainable. These respondents also believed that environmental sustainability should be a key factor in the construction of contemporary houses. The survey also indicates that despite efforts to enhance sustainability in house construction, the key barriers was perceived as the lack of adequate support from the government. Therefore, the government is urged to be on the forefront of more concrete provision. For example, building regulations and codes should be modified and enhanced to provide clear guidance that architects, designers, and users should follow. Also, architects and designers should be included in housing design such that they can inform their design through their professional practice. Moreover, the government must work in regulating the markets and promote the need to adopt specific design strategies for the design and build of future houses.

Finally, of 70 criterion identified as appropriate passive strategies for implementation in Baghdad contemporary housing to promote the uptake of a passive design, 63 were considered to be appropriate and applicable according to the expert participants. These included architectural strategies relating to: Massing and space layout, window design, shading strategies and natural ventilation; house envelope design including building envelope, external walls and rood, floor design and external design approaches. Based on the experts' suggestions, each design technique shown was confirmed to be to be applicable to Baghdad's current and upcoming weather conditions along with taking into consideration the city's cultural requirements and the availability of local raw materials.

The research has achieved objective 4: *Propose a framework for design strategies for new housing units in Baghdad, that appropriately combines contemporary technology with passive design fundamentals in order to provide comfortable and energy efficient housing solutions that are able to satisfy householder's functional expectations as well as social and cultural expectations and needs;* through undertaking a crictial synthesis of the results from the literature review, bioclimatic analysis, and the results of the surveys on the public's and experts'

perceptions. From this synthesis of fndings , three key passive design strategies have been identified as Shading, Natural ventilation, and Evaporative Cooling. These three strategies for the Baghdad city, selected using the bioclimatic design (chapter 4), are taken into consideration in combination with the findings from the literature review (Chapter 2), the public survey (Chapter 5), and the expert survey (Chapter 6) to develop appropriate strategies for this context.

With the aim of establishing a set of appropriate design approaches to inform future housing design in Iraq, which can enhance comfort levels yet decrease energy usage along with cultural responsiveness, a series of significant factors have been evaluated and identified. As a result, it is advocated that a mix of positive characteristics from both the vernacular house and contemporary house should be applied to future design strategies for a synthesized, sustainable house design for Baghdad that will provide better and naturally welcoming housing solutions that are able to satisfy functional expectations and social needs as well as respond to the energy and carbon challenges of a sustainable future. In particular, the design strategy recommendations are presented in Table 8.5 below.

Table 8.5: *The design strategies recommendations obtained by each theme*

Design strategies			**Passive design strategies The direct impact**	**Informed by:**
Urban fabric aspects	Compactness and street layout	Compactness	Self-shade +Natural ventilation	Vernacular house
		Walkability	Shading	
		Wider street \ Car access	Natural ventilation	
	Orientation		Natural ventilation and Heat gain	Vernacular house
	Outside zone	Courtyard	Shading+ Natural ventilation+ Heat gain + Evaporative cooling	Vernacular house
		Other aspects: Plant and water features		
Architecture design aspects	Form		Heat gain+ Shading +Natural ventilation	Vernacular house
	Window design	Size of window	Shading +Natural ventilation	Vernacular house\Contemporary house
		Shading device		
	Glazing design		Heat gain	Contemporary house
	Envelope design		Heat gain	Vernacular house\Contemporary house
	Roof terrace design		Sun shading +Natural ventilation	Vernacular house

The ***main aim*** of this research has thus been achieved:

> *Establishing a set of appropriate design approaches to inform future housing design in Iraq, which can enhance comfort levels yet decrease energy usage along with cultural responsiveness. Therefore, this study will consider the advantages of passive designs and vernacular courtyard houses for future architectural buildings in terms of both the local environment and cultural responsiveness.*

The conclusion of this work has been informed by four key phases of research. Firstly, a review of previous literature enabled an understanding of the current state of knowledge in this field of study and provide an academic basis for the identification of climatically appropriate passive design strategies, the socio cultural and environmental functioning of the vernacular housing of Baghdad and the evolution and current state of contemporary housing and urban, neighbourhood design in Baghdad. This work identified the challenges faced by both the vernacular and the contemporary housing in this context, as well as confirming the gap in knowledge as to the support and guidance for the construction industry as to what might be an acceptable typology, both socio culturally and environmentally for the future of contemporary sustainable housing for Baghdad.

Secondly, the study established the framework for theoretically appropriate passive design strategies for the Baghdad climate. Importantly this work then sought to establish the extent to which such strategies were acceptable and attractive to the general public, represented by the respondents to the public survey. This provided a vital additional perspective to the findings of both the literature and bioclimatic analysis, as without "market" satisfaction, acceptance and interest in both contemporary and vernacular houses with regards to environmental and cultural performance, a future synthesis of these that promotes both characteristics cannot be confidently applied to this industry. The final perspective drawn for this research, was that of the experts', where their perceptions for the potential for inclusion of passive design strategies in future Baghdadi housing designs were also evaluated. This last perspective was to serve as a proxy for the capacity of the industry to learn from and apply the outcomes of this study.

Findings from these four investigations: literature, bioclimatic analysis, public and professional perspectives were undertaken in the themes of the urban fabric, and

architectural design factors and findings were subsequently synthesised to inform decisions on those passive design strategies most appropriate for adoption in future designs for new housing in Baghdad. These future design strategies will require a combination of contemporary technology with passive design fundamentals in order to provide better and naturally welcoming housing solutions that can satisfy both functional expectations and social needs.

In conclusion, there are numerous strategies that can theoretically be applied to promote both socio-cultural and environmental sustainability in housing in Baghdad as confirmed by literature, bioclimatic analysis and expert opinion. This research has confirmed that expert capacity also exists within the local industry to understand and enable implement these strategies within a future synthesis of housing. Although this theoretical understanding of strategies may need further support to see delivery through training and guidance, including the widespread publication of guidance and recommendations such as those proposed by this study. There is also the need for governmental support for this transformation of the industry, potentially through enhancement to building regulation, planning guidance and other relevant strategies. Finally, the survey of occupants of both contemporary and vernacular houses has confirmed that there is interest and support for a "contemporary vernacular house" typology that embraces the benefits of both typologies through an effective synthesis of strategies,

Table 8.6 shows the design strategies recommendations obtained by each phase.

Table 8.6: *The design strategy recommendations obtained by each theme*

Design strategy		**Design solution**
Urban fabric aspects	Compactness and street layout	**Compactness** Walkability
		Wider street/ Car access
		Trees or palms
	Orientation	N-S
	Outside zone	Courtyard
		Trees, plants and fountains
Architecture design aspects	Form	Compact
	Window design	Size of window
		Shading device
	Glazing design	Consideration of application of double and triple glazing.
	Envelope design	Materials, thermal mass and insulation.
	Roof terrace design	Delivering privacy and shading

8.3 Contribution to Knowledge

The following points summarise the contribution to knowledge from this research:

1. A comprehensive literature review outlining the thermal comfort and energy efficiency challenge faced by dwellings in Baghdad, in the context of current standards and regulations. This includes a historical look at dwellings which focuses on vernacular designs used in Baghdad. For some aspects, there was a lack of peer-reviewed literature specific to Baghdad, in such cases, relevant literature relating to comparable climates was considered.
2. A bioclimatic analysis of building design relevant to the Baghdadi climate. The results indicate that the most efficient passive strategies for the whole year for Baghdad are the solar shading of windows, natural ventilation, direct evaporative cooling, and heating along with added humidification if required. All these strategies can be incorporated within a building to achieve as many hours as possible of comfort, energy saving, and enhanced low energy use in the climate of Baghdad. Many of the strategies favoured by bioclimatic building design could be found in Baghdadi vernacular dwellings but not in contemporary dwellings.
3. Examining the public's satisfaction with both contemporary and vernacular houses with regards to environmental and cultural performance. This information was used to inform decisions on which passive design strategies to implement in the design strategy for new housing in Baghdad.
4. Engaging with professionals and understanding their ideas on designs and construction in terms of passive designs of modern housing units in Baghdad, for example academic, government and private sector.
5. Propose a framework for design strategies for new housing units in Baghdad, as a case study, which required a combination of contemporary technology with passive design fundamentals to provide better and naturally welcoming housing solutions that can satisfy functional expectations as well as social needs. This research will develop a new approach to inform contemporary building design to assist developers, architects, contractors, academia, policymakers and the local authority of Baghdad with concepts that hence improve the construction of additional energy-saving and sustainable

buildings in Iraq and can be useful for other areas in Iraq and other similar cultural and climatic regions, such as Kuwait, Syria, and some areas of Saudi Arabia.

6. The Ministry of Planning, Iraq (2019) declared that Iraq has the potential to achieve sustainable developments and energy-efficient design by 2030 (Ministry of Planning, 2019). Hence, this research could contribute towards the aim of achieving low-energy buildings for 2030 through establishing a set of appropriate design approaches to inform future domestic building design in Iraq, which can both enhance comfort levels and decrease energy usage while remaining culturally responsive. The low cost of energy led to the disregard of energy-efficient design practices. The thesis acknowledges that because of the subsidized energy prices, individuals depend on using air conditioning as the main cooling source in buildings. This has discouraged architects from designing buildings that make the best use of passive design in hot seasons, which are the dominating season of excessive energy use in Baghdad buildings. This research could persuade the government to enforce an appropriate energy efficiency policy. The thesis acknowledges that the cheap energy supply and more widely available electricity has led to many new air conditioning applications. Intrinsically, the provision of thermal comfort became the responsibility of mechanical systems rather than the building.

8.4 Limitations of the Research

This research has experienced the following limitations, although all possible efforts were employed to overcome them and to avoid or minimize their influence on the processes, findings, conclusions, and recommendations of the study.

8.4.1 Limitation of the climatic data

- There was no recent climatic data in EPW format currently available for Baghdad, Iraq. The climatic data file used by Meteonorm in this research for the bioclimatic analysis had a maximum summer temperature of 46°C, although it has been noted from the researcher's experience, and for the year of this research in particular, that temperatures exceeded 50°C on some summer days in Baghdad. This variation is explained, to an extent, by the fact that most climatic data is normally obtained from airports, which are usually located in rural areas where the influence of the urban heat island is not effective. Conversely, the results would have been more representative if

a climatic data file, especially for Baghdad city, had been available. This was not possible, as there are no appropriate weather monitoring sites in the city.

8.4.2 Limitation of the respondents

The researcher acknowledges public survey response was short on:

- **Total number of respondents.**

  The questionnaire reached 112 participants, 98 of whom (87.5%) were interviewed and completed it successfully. Major restrictions were encountered when selecting the participant samples for the research which was viewed as significant. This is mostly due to security restrictions in Baghdad which limit freedom of movement around the city. This limited the number of participants for the survey. Another restriction was related to several religious ceremonies held in the country. As a result, the distribution of the questionnaires was subject to security provisions and there was no easy access during this period of time. The survey was therefore predicted to produce better results in a public club (Iraqi Hunting Club) and shopping mall to ensure that the researcher was also secure. Permission was given to the researcher from security agencies (Ministry Interior of Iraq and local security agency to the mall/club) to perform the survey. The security office provided one member of staff to ensure the personal safety of the researcher.

- **Survey Respondents: Vernacular House Occupants respondents.**
  - The researcher acknowledges the low proportion of candidates represented vernacular houses, 12/98(12%), due to the fact that many vernacular houses and neighborhoods lost their original residents, and today vernacular houses were sub-divided for multiple occupies by poorer households, as evidenced in literature review and personal observation.
  - Largely due to cultural reasons and other factors related to the nature of the study, which needed selective public participants (householders who are living in the vernacular courtyard type of house), the author could not reach a lot of participants in vernacular houses. Also, the distribution of the public questionnaires was subject to security provisions and there was no easy access during this period of time. The survey was therefore predicted to produce better results in a public club (Iraqi Hunting Club) and a shopping mall to ensure that

the researcher was also secure. However, it can be argued that this reduced the sample used for this research.

- The distribution procedure for both public and expert surveys used manual printed questionnaires and face-to-face interviews, which are slower and more expensive in comparison with an online survey. However, this process generates a more comprehensive response from individuals.

8.4.3. Limitation of the Questions

- The researcher acknowledges the limitation of some questions in the research, and encourages follow-on studies that extend the questions asked – in particular in the areas of:
    a. Public information and knowledge of highly efficient modern homes, (chapter5, Q19 and Q 22).

8.5 Recommendation for Further Research

Further work developing from this research includes:

- Develop more detailed strategies for application in housing design in Baghdad
- Use these strategies to inform building codes and planning guidance.
- Design case study homes applying the detailed strategies and simulate the thermal performance of these to assess performance in terms of energy efficiency and thermal comfort, when it is not possible to apply mechanical services (e.g. during power outage).
- Apply the methodology from this research to establish appropriate frameworks for strategies for low energy housing for other climatic areas in Iraq (northern and southern cities) or countries with similar cultures and climates where contemporary dwellings have replaced vernacular housing.
- Assess the economic impact of the whole life cost of a building with the suggested design strategies.

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Appendix A

EC1702·306

WELSH SCHOOL OF ARCHITECTURE
ETHICS APPROVAL FORM FOR STUDENT PROJECTS WS

Tick one box:	☐ UNDERGRADUATE ☐ M.ARCH ■ PhD
Title of project:	Applying Vernacular Design Principles of Iraqi Residential Buildings as an Approach to Low Energy Design
Name of student(s):	Noor Aalhashem
Name of supervisor:	Dr. Joanne Patterson
Contact e-mail address:	AalhashemNA@cardiff.ac.uk
Date:	2 Fab.2017

Participants		**YES**	**NO**	**N/A**
Does the research involve participants from any of the following groups?	• Children (under 16 years of age)		-	
	• People with learning difficulties		-	
	• Patients (NHS approval is required)		-	
	• People in custody		-	
	• People engaged in illegal activities		-	
	• Vulnerable elderly people		-	
	• Any other vulnerable group not listed here		-	
• When working with children: I have read the Interim Guidance for Researchers Working with Children and Young People (http://www.cardiff.ac.uk/archi/ethics_committee.php)				-

Consent Procedure	**YES**	**NO**	**N/A**
• Will you describe the research process to participants in advance, so that they are informed about what to expect?	-		
• Will you tell participants that their participation is voluntary?	-		
• Will you tell participants that they may withdraw from the research at any time and for any reason?	-		
• Will you obtain valid consent from participants? (specify how consent will be obtained in Box A)[1]	-		
• Will you give participants the option of omitting questions they do not want to answer?	-		
• If the research is observational, will you ask participants for their consent to being observed?			-
• If the research involves photography or other audio-visual recording, will you ask participants for their consent to being photographed / recorded and for its use/publication?			-

Possible Harm to Participants	**YES**	**NO**	**N/A**
• Is there any realistic risk of any participants experiencing either physical or psychological distress or discomfort?		-	
• Is there any realistic risk of any participants experience a detriment to their interests as a result of participation?		-	

Data Protection		**YES**	**NO**	**N/A**
• Will any non-anonymous and/or personalised data be generated or stored?				-
• If the research involves non-anonymous and/or personalised data, will you:	• gain written consent from the participants	-		
	• allow the participants the option of anonymity for all or part of the information they provide	-		

Health and Safety	**YES**	
Does the research meet the requirements of the University's Health & Safety policies? (http://www.cf.ac.uk/osheu/index.html)	-	

Research Governance	**YES**	**NO**	**N/A**
Does your study include the use of a drug? You need to contact Research Governance before submission (resgov@cf.ac.uk)		-	
Does the study involve the collection or use of human tissue? You need to contact the Human Tissue Act team before submission (hta@cf.ac.uk)		-	

[1] If any non-anonymous and/or personalised data be generated or stored, *written consent* is required.

Prevent Duty	YES	
Has due regard be given to the 'Prevent duty', in particular to prevent anyone being drawn into terrorism? https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/445916/Prevent_Duty_Guidance_For_Higher_Education_England_Wales_.pdf http://www.cardiff.ac.uk/publicinformation/policies-and-procedures/freedom-of-speech	-	

If any of the shaded boxes have been ticked, you must explain in Box A how the ethical issues are addressed. If none of the boxes have been ticked, you must still provide the following information. The list of ethical issues on this form is not exhaustive; if you are aware of any other ethical issues you need to make the SREC aware of them.

Box A **The Project** (provide all the information listed below in a separate attachment)

1. **Title of Project**
   Applying Vernacular Design Principles of Iraqi Residential Buildings as an Approach to Low Energy Design
2. **Purpose of the project and its academic rationale**
   The purpose of this research questionnaire is towards designing a framework that will facilitate the progress of design decision making by architects from briefing,through concept, and detailed design
3. **Brief description of methods and measurements**
   Architectures and expert in field will be interviewed and answer questionnaire form
4. **Participants: recruitment methods, number, age, gender, exclusion/inclusion criteria**
   Details of their profiles and years of experience as derived are detailed below.
   •Interviewee 'A' is an architect in academia with years of experience and a wide knowledge of different areas of design building ,sustainability and low energy issues in Iraq .also have a vast knowledge of legislation in design building
   •Interviewee 'B' is an engineer in academia with years of experience and a wide knowledge of different areas of design building
   •Interviewee 'C' is a practicing architect in practice with years of experience and a wide knowledge of different areas of design building and vast knowledge of sustainability and low energy design
   •Interviewee 'D' is an engineer in practice with years of design experience, construction and using materials
   •Interviewee 'E' is a people in practice- years of experience in design and construction.
5. **5. Consent and participation information arrangements - please attached consent forms if they are to be used (attached)**
6. **A clear and concise statement of the ethical considerations raised by the project and how is dealt with them**
   This questionnaire is part of study undertaken for obtaining a PhD degree. The questionnaire will take about 20 minutes to complete. I will mention that they do not feel obliged to answer a question if they do not wish to. Their response will be strictly confidential and used only for this academic research and also do not hesitate to ask any question and feel free to add their comments.
7. **Estimated start date and duration of project**
   My trip 11-12\2\2017 till 29\4\2017

All information must be submitted along with this form to the School Research Ethics Committee for consideration

Supervisor's declaration (tick as appropriate)

• I consider this research project to have **negligible ethical implications** and **the student can proceed with the research immediately** (*can only be used if none of the grey areas of the checklist have been ticked*).	X
• I consider this project research to have **some ethical implications. Box A** clearly describes the ethical issues and how they are addressed. **The student has to await feedback whether the research has been approved by the SREC Chair or whether it will have to be considered by the Committee**. The student will receive feedback within 7-10 days.	

nsider this project to have **significant ethical implications** and should be brought before e Ethics Committee. **Box A** clearly describes the ethical issues and how they are addressed. **The student MUST NOT proceed until the project has been approved by the Ethics Committee.**	

Signature Patterson **Name** JO PATTERSON **Date** 2/2/2017

Advice from the School Research Ethics Committee

STATEMENT OF ETHICAL APPROVAL

This project had been considered using agreed Departmental procedures and is now approved

Signature Juliet Davis **Name** JULIET DAVIS **Date** 13/02/17

Chair, School Research Ethics Committee

EC1808. 367

WELSH SCHOOL OF ARCHITECTURE
ETHICS APPROVAL FORM FOR STUDENT PROJECTS WS

Tick one box:	☐ UNDERGRADUATE ☐ M.ARCH ■ PhD
Title of project:	Applying Vernacular Design Principles of Iraqi Residential Buildings as an Approach to Low Energy Design
Name of student(s):	Noor Aalhashem
Name of supervisor:	Dr. Joanne Patterson
Contact e-mail address:	AalhashemNA@cardiff.ac.uk
Date:	17.7.2018

Participants		YES	NO	N/A
Does the research involve participants from any of the following groups?	• Children (under 16 years of age)		-	
	• People with learning difficulties		-	
	• Patients (NHS approval is required)		-	
	• People in custody		-	
	• People engaged in illegal activities		-	
	• Vulnerable elderly people		-	
	• Any other vulnerable group not listed here		-	
• When working with children: I have read the Interim Guidance for Researchers Working with Children and Young People (http://www.cardiff.ac.uk/archi/ethics_committee.php)				-

Consent Procedure	YES	NO	N/A
• Will you describe the research process to participants in advance, so that they are informed about what to expect?	-		
• Will you tell participants that their participation is voluntary?	-		
• Will you tell participants that they may withdraw from the research at any time and for any reason?	-		
• Will you obtain valid consent from participants? (specify how consent will be obtained in Box A)[1]	-		
• Will you give participants the option of omitting questions they do not want to answer?	-		
• If the research is observational, will you ask participants for their consent to being observed?			-
• If the research involves photography or other audio-visual recording, will you ask participants for their consent to being photographed / recorded and for its use/publication?			-

Possible Harm to Participants	YES	NO	N/A
• Is there any realistic risk of any participants experiencing either physical or psychological distress or discomfort?		-	
• Is there any realistic risk of any participants experience a detriment to their interests as a result of participation?		-	

Data Protection		YES	NO	N/A
• Will any non-anonymous and/or personalised data be generated or stored?				-
• If the research involves non-anonymous and/or personalised data, will you:	• gain written consent from the participants	-		
	• allow the participants the option of anonymity for all or part of the information they provide	-		

Health and Safety	YES	
Does the research meet the requirements of the University's Health & Safety policies? (http://www.cf.ac.uk/osheu/index.html)	-	

Research Governance	YES	NO	N/A
Does your study include the use of a drug? You need to contact Research Governance before submission (resgov@cf.ac.uk)		-	
Does the study involve the collection or use of human tissue? You need to contact the Human Tissue Act team before submission (hta@cf.ac.uk)		-	

[1] If any non-anonymous and/or personalised data be generated or stored, *written consent* is required.

Prevent Duty	YES	
Has due regard be given to the 'Prevent duty', in particular to prevent anyone being drawn into terrorism? https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/445916/Prevent_Duty_Guidance_For_Higher_Education_England_Wales_.pdf http://www.cardiff.ac.uk/publicinformation/policies-and-procedures/freedom-of-speech	-	

If any of the shaded boxes have been ticked, you must explain in Box A how the ethical issues are addressed. If none of the boxes have been ticked, you must still provide the following information.
The list of ethical issues on this form is not exhaustive; if you are aware of any other ethical issues you need to make the SREC aware of them.

Box A The Project (provide all the information listed below in a separate attachment)

1. Title of Project

A Framework for Future National Guidelines for housing in Iraq: Potential to Achieve Low Energy Design

2. Purpose of the project and its academic rationale

The purpose of this research fieldwork will toward testing a draft guideline that will facilitate the progress of design decision making by architects from briefing, through concept, and detailed design

Consultations with experts in Iraq will carry out depend on using the Delphi technique. These experts will appoint from different ministries and organisations related directly to the design and construction industry, such as the ministry of housing, the ministry of the municipality, engineering consultations, universities and construction companies(see table1).

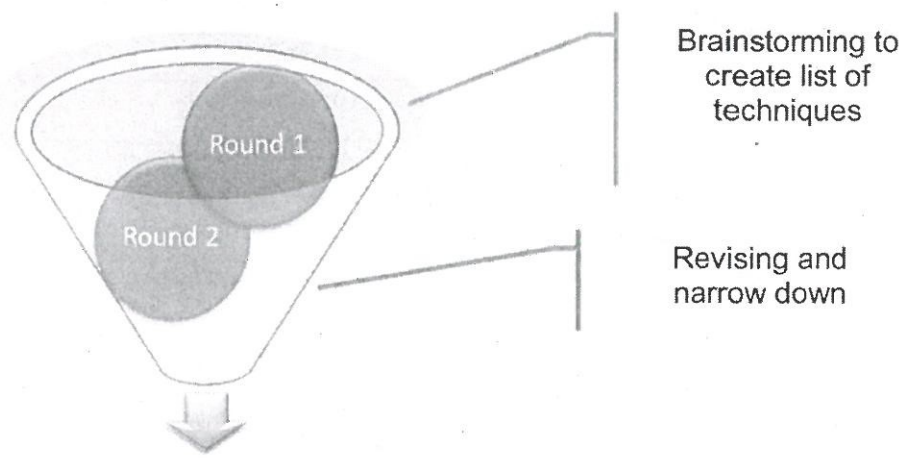
3. Brief description of methods and measurements

The consultation with experts will involve the use of the Delphi technique designed to achieve consensus among the members of a panel of experts. Experts in the field will interview and answer questionnaire form. The experts will involve in this study have a background in the construction industry with experience in vernacular architecture and low energy design.

for this study the Delphi Technique will require consultation with many different experts (see table 1) within two different rounds: (a) a brainstorming round to provide, assess and evaluate many different techniques and design strategies, based on experts' feedback and participation, and (b) with a final- narrowing-down round to reduce the huge number of strategies and techniques and identify the most efficient ones a consensus in the context of Iraqi climate and culture, based on experts' assessment.

The consultations will carry out with the same experts through two phases (rounds).In the first round of the consultation, the interviews will orginise to these experts across Iraq in different organisations. While, in the second round of the consultation, the questionnaires will distribute to these experts across Iraq in different organisations through email. The questionnaire in this round will update in accordance with the new techniques and design strategies put forward by the experts in the previous brainstorming round.

The idea was to obtain a rich and descriptive quality of data from a select group of participant responses rather than to achieve a high quantity of participants.



Designing low energy residantial buildings for Iraq(hot climate)

Delphi techniques-2 rounds

4. Participants: recruitment methods, number, age, gender, exclusion/inclusion criteria

The experts will invite to participate individually by interviews meeting face to face. All the experts will invite to participate in the study will provide with a confidentiality guarantee, which is crucial when implementing a Delphi consultation study.

Selection of a panel of experts will consider important to cover decision makers, academies and building professionals according to (Okoli and Pawlowski, 2004).

Table 1 presents the composition of the expert panel

* Okoli, C., & Pawlowski, S. D. (2004). The Delphi method as a research tool: an example, design considerations and applications. Information & management, 42(1), 15-29.

Category	Organization	Number of Experts	Expert Description
Academics	Baghdad University		Established academies (PhD holders) who research and in the fields of low energy design and vernacular architecture
	Technologia University		
	Al-Nahrain University		
	the University of Tikrit		
	Basra University		
	Al-Kufa University		
Decision-makers	Al rusafa Municipality		Decision makers with experience in low energy buildings and vernacular architecture. These experts have original qualifications in Civil engineering, Built Environment, and Architecture. They are responsible for granting planning consent in line with local regulations
	Al karah Municipality		
	Ministry of Municipality		
	Ministry of Housing		
	Ministry of environment		
	Housing Department – Design and Management and Construction in other Ministries		
Building Professionals	Ewaan Company for Construction in Baghdad		Engineering Consultants and construction practitioners in building design
	Sahar alqasy & Partnerships Leading Engineering and Construction Company in Iraq		
	Five design solutions (Engineering Consultations) in Iraq		
	Al-Mustaqbal Engineering Consultation Group		
	Engineering Consultation and Construction Company in Baghdad		
	Other Engineering Consultants		
Regional and International	Faculty of Engineering in UAE		Experts from international companies with experience in iraqi Context and the field of low energy design
	Faculty of Engineering - Jordan University of Science and Technology		
	Al Tamayaz Construction company - USA and Iraq		

Table 1 Composition of the Expert Panel

5. Consent and participation information arrangements - please attached consent forms if they are to be used (attach)

6. A clear and concise statement of the ethical considerations raised by the project and how is dealt with them

This questionnaire will be part of the study undertaken for obtaining a Ph.D. degree. The interviews questionnaire will take about 20 -30 minutes to complete. I will mention that they do not feel obliged to answer a question if they do not wish to. Their response will be strictly confidential and will use only for this academic research and also do not hesitate to ask any question and feel free to add their comments.

7. Estimated start date and duration of project

My trip 19\7\2018 till 26-27\9\2018

All information must be submitted along with this form to the School Research Ethics Committee for consideration

Supervisor's declaration (tick as appropriate)	
• I consider this research project to have **negligible ethical implications** and **the student can proceed with the research immediately** (*can only be used if none of the grey areas of the checklist have been ticked*).	✓
• I consider this project research to have **some ethical implications. Box A** clearly describes the ethical issues and how they are addressed. **The student has to await feedback whether the research has been approved by the SREC Chair or whether it will have to be considered by the Committee**. The student will receive feedback within 7-10 days.	
• I consider this project to have **significant ethical implications** and should be brought before the Ethics Committee. **Box A** clearly describes the ethical issues and how they are addressed. **The student MUST NOT proceed until the project has been approved by the Ethics Committee.**	

Signature JPatter **Name** JOANNE PATTERSON **Date** 18/7/18.

Advice from the School Research Ethics Committee

Add email of Supervisor in consent form; Add title of project in consent form. Add a sentence "The data will be managed in accordance to the general Data Protection Regulations and Data Protection Act".

STATEMENT OF ETHICAL APPROVAL

This project had been considered using agreed Departmental procedures and is now approved

Signature **Name** G ZAPATA-LANCASTER **Date** 3/8/18
Chair, School Research Ethics Committee

Consent Form - Confidential data

I understand that my participation in this project will involve answer some questions of study undertaken for obtaining a PhD degree about generating low energy residential buildings in Iraq, which trace the environmental and cultural values of the society and satisfy their spatial needs.

I understand that my participation is voluntary and that I am free to withdraw at any time without giving any reason and without there being any negative consequences. In addition, should I not wish to answer any particular question or questions, I am free to decline.

I understand that I am free to ask any questions at any time. I am free to withdraw or discuss my concerns with [*Dr. Joanne Patterson*].

I understand that my name will not be linked with the research materials, and I will not be identifiable in the reports that result from the research.

I agree for the data collected from me to be used in future research.

I, _____ consent to participate in the study conducted by [*Noor Aalhashem*], Welsh School of Architecture, Cardiff University with the supervision of [*Dr. Joanne Patterson*].

Signed:

Date: